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Practical Surveyor,

OR, THE
Art of *Land-Measuring*,
Made E A S Y.

Shewing by plain and practical Rules, how to Survey any Piece of Land whatsoever, by the Plain-Table, Theodolite, or Circumferentor: Or, by the Chain only. And how to Protract, Cast up, Reduce, and Divide the same.

LIKEWISE,
A New Method of Protracting Observations made with the Meridian; and how to cast up the Content of any Plot of Land, by Reducing any Multangular Figure to one Triangle: Being more exact and expeditious than heretofore used.

To which is added,

An A P P E N D I X,

Shewing how to Draw Buildings, &c. in Perspective, from Observations made by the New Theodolite, its Use in Levelling, in finding the exact Number of solid Feet, contained in any Timber Trees before they are cut down, by Inspection only; and also the Use of a new-invented *Spirit-Level*. With several other Things never before made Publick.

By SAMUEL WYLD, Gent.

L O N D O N:

Printed for J. HOOKE, at the *Flower-de-luce* against St. Dunstan's Church in *Fleet-street*: And J. SISSON, Mathematical Instrument-maker, the Corner of *Beaufort Buildings* in the Strand. M.DCC.XXV.

(Price Three Shillings.)

THE NATIONAL ANTHROPOLOGICAL ARCHIVES OF THE SMITHSONIAN INSTITUTION

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The records are arranged in chronological order, and are divided into two main sections: the first section contains the records of the Bureau of Ethnology, and the second section contains the records of the Bureau of American Republics. The records are arranged in alphabetical order within each section.

To which is added,
 A P P E N D I X
 showing how to find the records of the Bureau of Ethnology, and the Bureau of American Republics, in the National Anthropological Archives. This appendix is arranged in alphabetical order, and contains the names of the individuals and organizations who have contributed records to the National Anthropological Archives.

BY SAMUEL W. D. COLE

LONDON:
 Printed for J. H. B. at the National Anthropological Archives, 1890.
 (Price Three Shillings)



THE
P R E F A C E
TO THE
R E A D E R.



I N this small Tract you'll find the whole Art of Surveying Land Epitomized: The Rules and Methods here laid down in a plain and familiar Manner, being such as are fittest for a Practiser's Use, without an unnecessary Mixture of useless Curiosities and needless Repe- titions. And altho' Brevity be chiefly intended, yet nothing is here omitted, but what might well enough be spared in a Treatise that immediately relates to Practice.

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I know the common Objection will be raised by the Ignorant; that is, What needs any more Writing in this Kind, since so many Authors have, with great Ingenuity, bestowed no small Pains therein; (to whose Labours and Industry I acknowledge this Tract not a little beholding.) Now to this Objection, the old and common Answer must be returned, That *A Pigmy mounted on the Shoulders of a Giant, may see further than its Supporter.* And Arts Mathematical can never be so fully learned, but that there will still be new Experiments left for the Trial of others that succeed.

Besides, here are inserted, not only the most useful and Practical Methods yet extant in any other Author, but also a great many new Improvements never before made publick, rendring the Business of Surveying Land more exact, easy and expeditious.

The Book is divided into Seven Chapters, and the Appendix into Three, and these into several Sections, for the more orderly Ranging the several Subjects under their proper Heads.

In the First and Second Chapters, is described the Manner of Measuring Land by the most useful Instruments, the Plain Table,
Theo-

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Theodolite and Circumferentor ; the first being proper for Gardens, or such small Pieces of Land about Buildings, the second for larger Tracts of enclosed Land, and the third for Parks, Commons, &c.

In Handling this, I have not chose the most Accurate Method I could think of, but rather the most Plain and Simple, as being most Agreeable to the Conception of a Stranger to the Art, to whom nothing can be too plain.

In the Third Chapter, is described a new Way of Protracting Observations made in the Field, by the Needle: As also how to Cast up the Content of a Piece of Land, by Methods more facile and expeditious than heretofore used.

In the Fourth, the Use of the Theodolite is shewn in Surveying several Parcels of Land lying together ; with the Form of the Field-Book, and Plan of the Work annexed ; which shews, by Inspection only, the several Stations and Station-Lines throughout the whole ; from which the Observations are made in the Field.

The Fifth shews how to measure or plot any Piece of Land by the Chain only, without

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out the Help of any other Instrument in the Field but a small Cross.

The Sixth shews the Manner of Laying-out, and Dividing Land, without inserting the various Methods by which the same might be performed; but by such only as are the most easy and fit for Practice.

The Seventh shews how a County is to be Surveyed; as also Roads and Rivers; and how to make the Ground-Plott of a City, &c. And because these more seldom come in Practice, I only touch'd generally on the Manner how they are to be performed.

In the Appendix is described the Use of a new Spirit-Level, for Conveying Water to any appointed Place: Shewing also, how the Draught of a Building or other Objects, may be drawn in Perspective, from Observations made with the Theodolite, by a Method entirely new: As also how to find a true Meridian-Line, &c. These Problems, tho' not immediately related to the Business of Land-measuring, will be found very useful to a Practitioner in that Art, and may well deserve the little Room that is allotted them in this Book.

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It may be expected, here should have been inserted (as usual in Books of Surveying) more *Theorems*, &c. of Geometry ; I confess it is necessary a Surveyor should be well acquainted therewith, as also with Trigonometry, as the Ground-work of the rest. But then he may as well read in the Commentators on *Euclid*, the Demonstration of each Theorem at large (beginning with the Principles of the Art first) as to see 'em transcribed by Piecemeal any where else. Since the Two Theorems in the First Chapter, well understood and applied, will be sufficient for the Performance of most Problems relating to Land-measuring: And indeed, a Person who is well acquainted with the Use of his Instruments, will have little Occasion to have Recourse to Trigonometrical Calculations for finding his Angles, and for casting up the Content of any Piece of Land after the Plott thereof is made; the Directions in Sect. 4. may be sufficient: But if any one thinks otherwise, he may be farther informed from the Works of our Trigonometrical Writers, of which there are many good ones extant.

However, 'tis hop'd, the Country Farmer, who understands but so much of Arithmetick, as to add, subtract, multiply and divide (with a little Practice. the genuine Parent of Perfection) by these plain Directions, and with

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good Instruments, will be enabled to find the Content of each Piece of Land in his own Occupation, (and those who will not be at the Charge of Instruments, may make good Use of the Fifth Chapter,) and that this Knowledge is extremely necessary to the Countryman, none but the grossly ignorant will deny, since thereby he may judge what Stock of Cattle each Field will be likely to feed, or what Quantity of Seed will be sufficient for each Acre, or what Number of Workmen to reap or mow the same, &c. Which makes me admire, when I reflect, that this Science so beneficial to the Publick, as well as particular Persons, should be so much neglected, being so plain and obvious to every Capacity.

But I shall forbear any Panegyrical Expressions in Praise of the Art it self, (tho' much might be said on that Head) on Account of its Antiquity, Salubrity, Pleasantness, and above all, its Usefulness, *Ornari res ipsa negat contenta doceri.*

As for the Book it self, tho' perhaps some ill-natur'd Artists may be offended therewith, because several Things herein are discovered, (which they would have been as well pleased should have been concealed) like Flowers gathered and placed in one Garland, and prostituted to every one's View; yet if it
proves

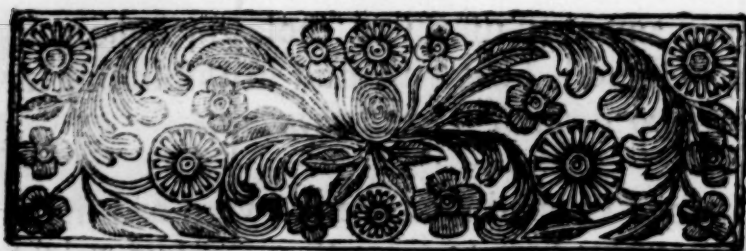
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proves any way useful to those for whom it was designed, I have my End in Publishing it.
Rumpatur quisquis rumpitur invidia.

Indeed I hoped some Person who had more Hours of Leisure to spare than my self, might have spent some of them in Composing something of this Nature, since all the Books I have yet seen are much deficient in many of the most necessary Parts of the Business, or else too voluminous for common Use ; but could not hear of any such, till this was in the Press, and several Sheets wrought off, else I should gladly have resigned the Task : But now that it is printed, e'en let it be published ; and at the Bookseller's Request, I have added thus much by Way of Preface, which I shall conclude with a Saying I have somewhere met with, *Va, mon Enfant, prend ta Fortune.*

S. W.





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ADVER.



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BECAUSE the Practice of SURVEYING depends much on the *Instruments* used therein, which, being ill-contrived and adjusted, cause unavoidable Errors: Therefore I thought fit to say, That all Sorts of Instruments for Surveying Land, are made with the greatest Accuracy and newest Improvements,

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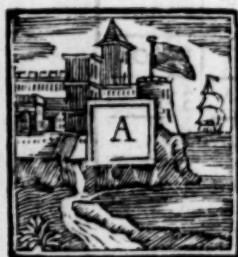


THE Practical SURVEYOR:

CHAP. I.

*Shewing how to make a Plott of a
Piece of Land by the Plain Table,
and cast up the Content thereof.*

SECT. I.



Geometrical Superficies or Surface, is produc'd or form'd by the Motion of a Line, as that is describ'd by the Motion of a Point, for if $a b$, in *Fig. 1.* be equally mov'd upon the same Plane to $c d$, then will the Points at a and b , describe the two Lines $a c$, and $b d$; and by so doing, they will generate the Superficies or Figure $a b c d$, being the Quantity of two Dimensions, *viz.* it hath Length and Breadth (but not Thickness,) consequently the Bounds or Limits of a Superficies are Lines; so if the Line $a b$, doth contain in Length five Chains, and the Line $a c$

B

two

two Chains, and if their opposite Sides and Angles be equal, the Quantity of Land these four Lines enclose, viz. (*a b*, *b d*, *d c*, and *c a*.) will be an Acre.

Our present Business therefore, will be to compute what Number of such Acres, or Parts of an Acre, are contain'd in any Piece of Land, (be it Arable, Meadow or Woodland) whose Extent is limited by certain Lines or Bounders. Now an Acre of Land (by the Statute of 33. of *Ed. I.*) is appointed to contain 160 square Perches or Poles; it is no matter in what Form it lyes, so it contains 160 square Poles; and *Gunter's Chain* (the best for Practice) being therefore made four Pole long, ten of these square Chains make an Acre, (that is to say) one Chain in Breadth, and ten in Length, or two in Breadth, and five in Length, &c. do contain 160 square Poles, as *per Statute*. See the following Tables.

1 Table of long Measure.

Inches	Link	Foot	Yard	Perch	Chain	Mile
Inches	7. 92	12	36	198	792	63360
	Links	1. 515	4. 56	25	100	8000
		Feet	3	16. 5	66	5280
			Yard	5. 5	22	1760
				Perch	4	320
					Chain	80

Chains	Links	Pts. of a Link
1	10	00
2	5	00
3	3	33
4	2	50
5	2	00
6	1	66
7	1	42
8	1	25
9	1	11

Length of an Acre

Breadth of an Acre

A Table

A Table of Square Measure.

Inch	Inch	Links	Feet	Yards	Poles	Chains	Acre
Links	62726	1					
Feet	144	2295	1				
Yards	1296	20755	9	1			
Poles	39204	625	27225	30.25	1		
Chains	627264	10000	4356	484	16	1	
Acre	6272640	100000	43560	4840	160	10	1

A Table, shewing how many Chains, Links, and Parts, are contain'd in any Number of Feet, from 1 to 10000.

Feet	Chain	Links	Pts. of Links	Feet	Chain	Links	Pts. of Links
1	0	1	515	200	3	03	030
2	0	3	030	300	4	54	545
3	0	4	545	400	6	06	060
4	0	6	060	500	7	57	575
5	0	7	575				
6	0	9	090	600	9	09	090
7	0	10	606	700	10	60	606
8	0	12	121	800	12	12	121
9	0	13	636	900	13	63	636
10	0	15	151	1000	15	15	151
20	0	30	303	2000	30	50	303
30	0	45	454	3000	45	45	454
40	0	60	606	4000	60	60	606
50	0	75	757	5000	75	7	757
60	0	90	909	6000	90	90	909
70	1	06	060	7000	106	06	060
80	1	21	212	8000	121	21	212
90	1	36	363	9000	136	36	360
100	1	51	515	10000	151	51	515

The Use of these Tables is plain by Inspection, therefore particular Directions are needless.

Let Figure 2 be suppos'd to represent a Piece of Land, bounded with the four strait Lines $a b$, $b d$, $d c$, and $c a$, whose Lengths are each ten Chain, then the Area or Superficies thereof will contain ten times ten square Chains, or ten Acres, (as *per Fig.*) each of the small Squares representing one square Chain.

But before the Plan of any Piece of Land can be laid down (or protracted) on Paper, in order to make a Computation of the Area or Quantity of Superficies it contains, 'tis necessary we should know the Length and Position of the several Lines that bound the same.

And to find the Length and Position of Lines in the Field, we make use of Instruments, *viz.*

To measure the Length of Lines in the Field, we use *Gunter's Chain*, containing in Length four Poles or 66 Feet, divided into 100 Parts or Links, each Link being 7 Inches, and $\frac{2}{10}$ of an Inch, and a Staff whose Length is equal to $\frac{1}{10}$ part of the Chain; that is to say, 10 Links, or 6 Foot 7 Inches $\frac{2}{10}$ of an Inch. For Roads the Wheel.

Instruments us'd for taking the Position of Lines, are of two Kinds. With some we take the Position of a Line by the Angle which it makes with the Meridian, using a Box and Needle, as the Circumferentor, &c. and this is usually call'd the Bearing of the Line.

With others we take the Position by the Angle that the Line makes with any other given in Position; as with the Limb of the Theodolite, the Chain, &c.

But with some we take the Angle it self as with the Plain Table, &c.

All other Instruments either differ from these only in Name, or are contain'd in them.

The

The Instruments for Plotting, are a Scale and Compasses, or rather a Scale decimally divided close to the Edge, and at every tenth Division, numbred 0, 1, 2, 3, &c. denoting Chains, and a Protractor always to be divided, numbred, and fitted to the Instrument.

Of the use of these several Instruments in their Order; and first of the Plain Table; the Uses thereof being as plain as the Name of the Instrument denotes.

But because we make use of the Chain in all manner of Business in the Field, it will be necessary, in the first place, to inform our selves in the manner how to manage it in measuring the Length of Lines in the Field.

S E C T. II.

• *Directions for measuring with the Chain.*

The Chain contains in Length 4 Pole or 66 Feet, divided into 100 Links, each Link being $7\frac{2}{5}$ Inches, as aforesaid, having a large Ring exactly in the middle of the Chain, and pretty large Pieces of Brass of different Shapes at the end of each 10 Links, for the speedier counting of the odd Links; also you may tie a large red Rag at 50 Links, and others of a lighter Colour at 25, from each end of the Chain, especially when the Grass is long.

Take care that they who carry the Chain deviate not from a strait Line, (that being the nearest Distance that can be between any two Places,) for if the Lines be not exactly measured, neither the Form nor Content of the Plott can be true. Provide a Staff just six Foot seven Inches and $\frac{1}{10}$ long, which divide into 10 equal Parts, so will the Whole be the Length of 10 Links, and each Part the Length

of one Link, and 10 times the Length of this Staff (which you may call the off-set Staff) the Length of the whole Chain; also provide 9 Arrows or small Sticks above a Foot long, which you may mark at the Tops with Bits of red Cloath, and at the Bottom you may put small Iron Ferrills and two strait Staves about 5 Foot each.

Before you measure with the Chain, 'tis necessary to examine its Length by the off-set Staff, stretching it on level Ground in such sort, as when you measure with it.

Being thus provided, let the Leader of the Chain take the nine Arrows in his Hand, and one of the 5 Foot Staves, and let the Follower, standing at the Station, direct him to place his Staff at the Chain's End, in a right Line with the Stations, and there to put down one of his Arrows, and then go on.

Let the Follower, being come to the Arrow, take it up, and put his Staff in the place thereof, and direct the Leader to place his Staff as before; then let the Leader, standing at his Staff, look back towards the last Station, and he will see the two Staves and the Station in one right Line, if they have directed right; but if not, the Leader must direct the Follower to place his Staff in the same right Line with the Station and the Leader's Staff, and so must each direct the other, till the two Staves and two Stations are in one right Line.

Let 'em thus proceed till they have measured to the Station, or till the Leader is nearer the Station than one Chain's Length; then will the Number of whole Chains measured, be express'd by the Number of Arrows prick'd down, suppose 7; and the Leader holding the End of the Chain to the Station, the Fol-
lower

Sect. 2. The Practical Surveyor.

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lower will see how many Links are contain'd between the Station and last Arrow, suppose 60.

Now enter in the Field Book, the Chains and Links without any Distinction between them, and they will be 760 implying either 760 Links, or 7 Chains 60 Links; but the Links must always possess two Places after the Chains, as 7 Chains 4 Links must be written 704, and not 74; and 8 Chains must be written 800, also as soon as you have measur'd each Length, enter it down immediately in the Field Book, and never trust to your Memory; also at the end of each Length, enquire of the Leader and Follower how many Arrows each have in their Hands, and if the Sum of the Arrows are not nine, the last measur'd Length is doubtful, and must be re-measur'd before you proceed.

When the Length is above nine Chains, let the Leader go on, and set his Staff down at the tenth, and let the Follower put his Staff in the place of the Leader's, and give the Leader the nine Arrows, and then proceed as before; but enter these 10 Chains immediately in the Field Book, and if the Length is 10 Chains more, enter 20; also observe it is usual to allow 5 Links from the Stem of the quickset Hedge, for the Breadth of the Ditch, except the Custom or Agreement is otherwise; but the Custom of the Place generally is the Surveyor's Rule.

S E C T. III.

Shewing how to make a Plott of one Field, or several Fields, upon the Paper on the Plain Table, by placing the Instrument at one or more Stations about the Middle, from whence the Angles may be seen.

Let Fig. 3. be suppos'd to represent two Fields or Enclosures, a Plott of which is desir'd, and first of the Field, *a l m o b.*

Having put your Plain Table in order, and observ'd the Needle to play well, put a Sheet of fair Paper thereon, and crush down the Frame, so that the Paper lyes smooth; then you may imagine the Paper on the Table to represent the Surface of the Land, and the Lines you shall draw thereon, to be the Bounders of the respective Fields or Enclosures in some Proportion or other, and if you make the Proportion thus, A Line drawn on the Paper an Inch long, is equal to, or in proportion to, the Length of one Chain on the Land, and if 5 Chains in Length, and 2 in Breadth, do contain the Quantity of one Acre on the Land, then 5 Inches in Length, and 2 in Breadth, shall also contain the Quantity of one Acre on the Paper, and takes up the same Quantity of Space thereon, as an Acre does in the Field; *vide Fig. 1.*

This being premis'd, we proceed to lay down the Lines that enclose these two Fields of the same Length and Position on the Paper, which shall therefore include the same Quantity of Superficies as those in the Field it self in proportion, as 1 Inch to 1 Chain.

But if we make half, or a quarter of an Inch, or half a quarter (by which the following
Di-

Dimensions were laid down) on the Paper, to represent one Chain, it is the same in effect, only the Plott thereby is made lesser; also the Inches, &c. on the Paper, are capable of being subdivided, as the Chain is into Links.

First, place the Table somewhere about the middle of the Field, from whence, if possible, you can see all the Angles, as at $\odot$, and make an Hole in the Ground, over which by the help of a Plummet and String, set the Center of the Table, by applying the String to the head of the Staff, and having set the Instrument steady on the Ground, turn the Table about till the Needle hangs over the Flower de Luce in the Box, (or if 'tis more convenient, turn the Length of the Table to the Length of the Plott, that it may, if possible, lye on one Sheet of Paper, and note, on a Bit of waste Paper, the Division in the Box the Needle hangs over when at rest,) and then screw the Table fast. Assign on the Paper a Point, or stick a Pin at $\odot$, (to represent the Hole in the Ground or present Station) to which Point, apply the fiducial Edge of the Index, and turn it about, keeping the Edge close to the Point or Pin at $\odot$, till through the Sights you see the Hair cut a Staff or Mark, set up exactly in one of the Angles, as at a , then by the Edge of the Index, draw a Line from the Point $\odot$ towards the Angle a , with the Point of the Compasses, without regarding the Length, so it be long enough.

Let the Mark be left at a , and cause others to be set up round the Field, at every Angle therein, as at $l m o b$, to every one of which direct the Sights, and when the Hair therein cuts the Mark (keeping the Edge of the Index close to the Point $\odot$) draw the several Lines $\odot l$, $\odot m$, $\odot o$, $\odot b$.

Now

Now see whether the Needle continues to hang over the same Point in the Box as when you first planted the Table, also lay the Edge of the Index to the Line $\odot a$, and if then the Hair in the Sights cuts the Mark at a , and the Needle hangs over the same Point as at first, you may conclude the Table hath not been mov'd out of its first Position, which is carefully to be observ'd.

In the next place we proceed to make the Lines $\odot a$, $\odot b$, &c. of their just Length, and to that end apply the Ring at one end of the Chain to the Hole under the Table, and let the Chain be stretch'd at length towards one of the Angles as at a , and when I have measured up thereto, (observing the Directions before laid down for measuring with the Chain,) I find the Length of the Line $\odot a$, to contain 3 Chains 60 Links, or 360 Links, which note in a Bit of Paper.

Having found the Length of the Line $\odot a$ on the Ground, I proceed to make that on the Paper of the same Length, to correspond therewith in Proportion, as an Inch to a Chain, or any other Proportion as shall be most convenient.

Therefore having provided a Scale and Compasses, because the Length of the Line I am about to take off, is 360, or 3 Chains 60 Links: I set one Foot of the Compasses in the Line of Inches, &c. at 1, and extend the other to 60 in the diagonal Divisions; thereby taking off 360 Links, then the Compasses remaining at this Extent, I set one Foot in the Point $\odot$ on the Paper, and let the other fall in the Line $\odot a$, where I make a visible Mark or Prick with the Compass Point, in order to find it again presently.

Note, each whole Inch, $\frac{1}{2}$ Inch, &c. on the Scale, represents one Chain, and the Links, or hundredth Parts of the Chain, are taken off from one whole Inch, $\frac{1}{2}$ Inch, &c. divided also into 100 Parts,
by

by diagonal Lines drawn cross the Scale; for each 10th of that Division represents 10 Links, and is divided into other ten Parts, by the crossing of the diagonal Lines. Any Instrument-maker that sells this Scale, will presently shew the Uses of these Lines, or the Sight thereof will be a sufficient Information; only it may be observ'd, that these Scales are best made of Brasses, and the Joints of the Compasses are chiefly to be observ'd, which should have an equal easy Motion without leaping, and that the Points be well temper'd, and close in a Point exactly.

Observing the Directions before laid down, I first measure with the Chain the Length of the several Lines $\odot l$, $\odot m$, $\odot o$, and $\odot b$, and then transfer the Length of each Line on the Ground to its Representative on the Paper, making visible Marks where the end of each Line falls, as at a , l , m , o , b .

And here it may be observ'd, that I generally measure one Line from the Instrument to an Angle, and the next from the Angle to the Instrument, till all are finish'd, and note the Length of each Line as I measure it in a Piece of waste Paper, and never trust to my Memory; then observing which Line I began with, I set on its true Length on the Paper on the Table, and the rest of the Lines in their order.

Lastly, I join the Points a , l , m , o , b , with Ink Lines, because they should not rub off, (and for this purpose a drawing Pen is requisite,) as the Lines $a l$, $l m$, $m o$, $o b$ and $b a$, which constitute the Bounders of the Field $a l m o b$.

It may be a young Beginner will take some Pleasure to measure cross some part of the Plott on the Paper, as the Distance from a to o , or from a to b , with his Scale and Compasses, and afterwards measuring the same Distance on the Ground with the Chain, he will find them both exactly to agree, if the Plott be truly laid down. Ha.

Having finish'd this Field, I cause a Staff to be set up with a Paper thereon in the next, in a convenient Place, from whence I can view all the Angles; but if such a Station can't be found, I chuse the most convenient as at $\odot 2$.

The Table standing at $\odot 1$, in the Field *a l m o b*, in the same Position as at first, (which it must do, or the Plott of the next Field can't be truly laid down in respect of the last) I lay the Index to the Point $\odot$, and turn it about thereon, till the Hair in the Sights cuts the Staff or Mark in the next Field at $\odot 2$, and holding the Index fast in that Position, I draw a Line by the Edge thereof, from $\odot 1$, towards $\odot 2$, in the next Field, and take care to continue it long enough; then remove the Table, and place a Staff with a Mark thereon, in the Hole over which the Center of the Table was plac'd, and measure with the Chain the nearest Distance between $\odot 1$, (in the Field *a l m o b*), and $\odot 2$ in the next Field, (drawing the Chain through the Hedge in a strait Line, and set on the Distance $\odot 21$, (by the Help of the Scale and Compasses) from $\odot 1$ to $\odot 2$.

Now I take away the Staff, and plant the Center of the Table over the Hole, in which the Staff stood at $\odot 2$, and sticking two Pins, or the Points of two small Needles in $\odot 1$, and $\odot 2$, apply the Edge of the Index thereto, so as it lyes exactly on the Line $\odot 1, \odot 2$, and keeping it in this Position, turn the Table about till the Hair or Thread in the Sights cuts the Staff or Mark in the last Field, and then screw the Table fast that it stir not out of this Position, till I have finish'd the Observations in this Field, (but observe to turn that Part of the Table mark'd with $\odot 1$, towards its Representative in the last Field.)

When

When the Needle hath settled, and is at rest, observe whether it hangs over the Flower-de-luce or same Division in the Box, as at $\odot 1$ in the last Field; which it will do if you have made your Observation truly, and the Needle be good; and if you were to move the Table to never so many Stations, the Needle will still point to the same Division in the Box, which observe; because the removing the Table from one Station to another is the greatest Difficulty in this Way of Surveying.

Having caus'd Marks to be set up in so many of the Angles in this Field, as you can conveniently see, from the present Station, as at k, i, b, g , lay the Index to the Point $\odot$, and direct the Sights, to k, i, b, g , drawing Lines by the Edge of the Index towards every one of them; then measuring the Length of the several Lines $\odot k, \odot i, \odot b, \odot g$, with the Chain, set on the several Lengths of these Lines on the respective Lines on the Paper (as before directed,) marking the Points k, i, b, g , where the Ends of the Lines fall from $\odot$: Lastly, join the Points lk, ki, ib , and bg , with ink Lines, and they constitute the Bounders of so much of the present Field, as you can conveniently see from this Station.

But there is no occasion to measure to the Angles l or m with the Chain, except that it may be some Satisfaction, as aforesaid, to see the Lines on the Paper, and those on the Ground to agree.

Observing the former Directions for removing the Table, let it be plac'd in its true Position at $\odot 3$ in this Field; and direct the Sights to the Angles f, e, d , and c , and when the several Distances from $\odot 3$, to f, e, d and c , are set on the Paper, join the Points gf, fe, ed, dc , and cb , with ink Lines, so is the true Plott of these two Fields, $almo b$, and $lkibgfed c l o m$, laid down on the Paper in such Proportion

portion, as the Scale you made use of is to the Chain.

But observe that if the Hedge bc , had been so thick, that from $\odot 3$, you could not have seen the Angle d , or other Obstruction had hinder'd your Sight or Measuring thereto, you must have remov'd the Table to another Station; but when you can (as commonly you may) by holding aside the Boughs or otherwise, see the Mark, and by drawing the Chain through the Hedge, measure the Line from $\odot 3$, to the Angle d , 'tis a better way than to remove the Table, for the fewer Stations you make, the better, and the Work will be more truly laid down, which remember.

It would be only repeating the same thing over again, to give Directions how to survey a Field from a Station taken in any Angle thereof, from whence the rest may be seen; as if it had been more convenient in the Field $almob$, to have planted the Table at the Angle a , the Sights must have been directed from thence to the rest of the Angles l, m, o, b , and the Lines measured on the Ground, from a to l, m, o and b , whose Length laid down on the Paper from a , would give the same Points l, m, o, b , as if the Station had been in the Middle of the Field, and when the Bounders are drawn, they will be in the same Position as before.

If you would draw a Meridian, or a North and South Line through the Plott, turn the Table about, till the Needle hangs over the Flower-de-luce in the Card, and laying the Index on some of the equal Divisions on the sides of the Frame, draw a Line close by the Edge, which shall be a meridian Line; and if you cross this Line by another at Right Angles, that shall shew the East and West Points.

S E C T. IV.

S E C T. IV.

Directions for casting up the Content of any Piece of Land.

The next thing that lies before us is the **Manner** of Calculating the **Quantum** of the **Superficies** enclosed by the **Lines** on the **Paper**, as they represent the **Bounders** in the **Field**; that is to say, how many **Acres**, and **Parts of an Acre** are contain'd therein.

In order thereto, these several Things may be premised: First, That every Magnitude is mensurable by some Magnitude of the same Kind; as, a Line by a Lineal Foot, &c. a Superficies by a Square Foot, &c. and a Solid by a Solid Foot, &c. The Superficial Measure may be conceived, by imagining *Fig. 2.* to be a Field, as now divided into 100 Squares, every Square being one Chain, having a Chain for its Side: Now if the Field be just one Chain broad, the Number of Square Chains will be equal to the Number of Lineal Chains in the Length of the Field: But if the Field be 2, 3, 4, &c. Chains broad, the Number of Square Chains will be twice, thrice, or four times so many square Chains; so this Field being 10 Chains long, and 10 Chains broad, the Number of square Chains in it are, 100, viz. 10 multiply'd by 10, gives 100; or if it had been 40 Chains long, and 5 broad, the Number of square Chains would be 200.

2. That the Mensuration of all superficial Figures, as Land, &c. depends on the exact Measuring of certain regular Figures, as the Parallelogram, Triangle, &c. so that if any Plot of Land be not one of these Figures, it must be reduc'd into some

some or one of these Forms before it can be measured.

3. A Parallelogram is a quadrilateral Figure, each of whose opposite Sides are parallel, and the Diagonal divides the same into two equal Parts, as the Parallelogram $abcd$, Fig. 5. the opposite Sides and opposite Angles of which are equal between themselves, and the Diameter or Diagonal ac bisects the Parallelogram.

4. A Right-lin'd Triangle, is a Figure comprehended within three strait Lines.

We need not here take notice whether a Triangle be Right or Oblique-angled, or by what Name distinguish'd, whether an Isosceles, Scale-num, &c. because they are all measured by one and the same Rule.

5. A Trapezia is an irregular four-sided Figure, comprehended under 4 unequal Sides and Angles.

To this we shall add these two useful Theorems following.

Theorem 1.

That Parallelograms constituted upon the same Base, and between the same Parallels, are equal, *Euclid. lib. 1. Prop. 35.*

Let $abcd$, $ebcf$, be Parallelograms constituted upon the same Base bc , and between the same Parallels af , and bc , then the Parallelogram $abcd$, is equal to the Parallelogram $ebcf$.

For because $abcd$ is a Parallelogram, ad is equal to bc , and for the same Reason ef is equal to bc , wherefore ad shall be equal to ef , but de is common, therefore ae is equal to df , but ab is equal to dc , wherefore ea , ab , the two Sides of the Triangle abe are equal to the two Sides fd , dc , each to each, and

and the Angle $f d c$, equal to the Angle $e a b$, the outward one to the inward one, therefore the Base $e b$ is equal to the Base $f c$, and the Triangle $e a b$, to the Triangle $f d c$.

If the common Triangle $d g e$ be taken from both, there will remain the Trapezia $a b g d$, equal to the Trapezia $f c g e$, and if the Triangle $g b c$, which is common, be added, the Parallelogram $a b c d$, will be equal to the Parallelogram $e b c f$, which was to be demonstrated. *Vide Fig. 4.*

Theorem 2.

If a Parallelogram and a Triangle have the same Base, and are between the same Parallels, the Parallelogram will be double to the Triangle, *Euclid. Lib. I. Prop. 41.*

Let the Parallelogram $a b c d$, *Fig. 5.* and the Triangle $e b c$, have the same Base, and between the same Parallels $b c$, $a e$, then the Parallelogram $a b c d$, is double the Triangle $e b c$.

For join $a c$, then the Triangle $a b c$ is equal to the Triangle $e b c$, for they are both constituted upon the same Base $b c$, and between the same Parallels $b c$, $a e$, but the Parallelogram $a b c d$, is double the Triangle $a b c$, since the Diameter $a c$ bisects it, wherefore likewise it shall be double to the Triangle $e b c$, which was to be demonstrated. *Vide Fig. 5.*

By the last *Theorem*, a Parallelogram having the same Base with a Triangle, and lying between the same Parallels, is double to the Triangle; therefore if the Base of a Triangle be of the same Length with one side of a Parallelogram, and the Perpendicular of the same Height, as the other side of the Parallelogram, those Triangles are equal but to half that Parallelogram. *Vide Fig. 6.*

If a Weight (as a Bullet) was suspended at *e*, *Fig. 6.* and from thence let fall on the opposite Line *bd*, it wou'd describe the Perpendicular Line *ef*, then a Perpendicular is the nearest Distance, or shortest Line that can possibly be drawn from any Angle to its opposite Side.

And here it may be convenient to insert the Manner of raising or letting fall a Line perpendicular to another.

Let a Perpendicular be raised on the Line *de*, from the Point *c*, *Fig. 7.* Open the Compasses to a convenient Distance, and mark out the two Points *a* and *b*, then opening them something wider, you may by setting one Foot in *a* and *b*, severally describe the two Arches cutting one another at the Point *f*, from which draw the Perpendicular *fc*, to *c*, also the Line *fc*, continued, will cross the Line *de*, at Right Angles.

Let a Perpendicular be raised from the End of the Line *ab*, at *b*, *Fig. 8.* Open the Compasses to an ordinary Extent, and setting one Foot in the Point *b*, let the other fall at Adventure, as at *e*, then without altering the Extent of the Compasses, set one Foot in the Point *e*, and with the other, cross the Line *ab*, at *d*, and describe the obscure Arch *dd*, then lay the Ruler to *d* and *e*, and draw the obscure Line *d e*, through the Arch. Lastly, apply the Ruler to the Point of Intersection at *f*, and to the Point at the End of the Line *ab*, and draw the Perpendicular *cb*.

Let a Perpendicular be let fall from the Point *c*, upon the Line *ab*: Set one Foot of the Compasses in the given Point *c*, and with the other, describe such an Arch of a Circle, as will cross the given Line *ab*, in two Points, viz. *d*, *f*, then bisect the Distance between the

two Points *d* and *f*, as at *e*, and draw the Perpendicular *c e*.

This is no more but the First Problem reversed: Also a Perpendicular may be let fall nigh the End of a Line by the Second.

Note, Those Problems touching Perpendiculars, aim at no greater Matter, than may be performed in a mechanical Way, by the help of a small Square, exactly made as a Square Protractor, or for want thereof, a Scale in a Case of Instruments, that hath a Right Angle, and true Sides, or the Square therein, in the Form of a Carpenter's, &c. for if you apply one Leg of such a Square to any Line, so as the Angle of the Square may touch the End of the said Line, or any other Point where the Perpendicular is to be raised, you may by the other Leg, draw the Perpendicular. In like manner may you let fall a Perpendicular from a Point assigned, by applying one Leg of the Square to the Line, so as the other may touch at the same Line the assigned Point, whence you may draw the Perpendicular by that Leg that touches the Point.

If the Angle of the Square, be a little Blunt by Wearing, you must allow for it when you apply it to the Point in a Line, and when you are drawing a Perpendicular, you must stop before you reach the given Line, and then by applying the Leg of your Square, to that Part of the Perpendicular already drawn, so as that Part of the Leg may pass clearly over the Line, you may draw the Perpendicular as exactly, as if the Angle had been true. The like Course is to be taken, when a Line is to be crossed by another drawn quite through it at Right Angles.

6. Every Figure enclosed with 3 Right-lines is a Triangle, and in the Mensuration thereof, only the Length of the Base, and Height of the Perpen-

dicular is considerable, and any of the Lines may be made the Base, though commonly the longest is, and a Line let fall from the opposite Angle upon, or made to touch the Base in the nearest Point, is the Perpendicular, and you are not confin'd to any Angle, but may let fall the Perpendicular from what Angle you please, taking the Line on which it falls for the Base.

7. The Area or Content of the two Primitive Right-Lin'd Figures, the Square or Parallelogram and Triangle is found by multiplying the Length of the Square or Parallelogram by its Breadth, and the Base of the Triangle by half the Perpendicular, or the whole Perpendicular by half the Base, or the whole Base by the whole Perpendicular, then the half of that last Product, is the Content of the Triangle.

And here it may be worth observing, that the Multiplier in any of the Multiplications made use of in casting up any Mensuration, is an abstract Number, as well as in all other Multiplications whatsoever, which may prevent the false Consequences usually drawn from multiplying Feet, &c. by Feet, (*viz.*) that of multiplying by a contract Number (as half a Crown by half a Crown) which is contrary to the Nature of Multiplication, whose Operations are only compendious Additions, either of the Multiplicands, or some Part of it continually to its self or its Part.

8. The Parallelogram or Square, being the original Figure from which are deduced all Computations, that relate to the casting up the Content of a Superficies, a Line drawn from any Angle therein to its opposite Angle, may be divided into two Triangles (which dividing Line is called the Diagonal, as aforesaid) both of which Triangles taken together, are equal to the
the

the Square or Parallelogram, and one of them equal to half of it, and any manner of Figure that hath four Sides, whether equal or parallel, or neither, let it be called a Trapezia-Rhombus, &c. is capable of being divided and cast up in the same manner.

9. Then any irregular Figure, let it consist of never so many Sides, may be divided by such Diagonals into a Number of Triangles, &c. which separately cast up and added together, their Sum is the Content of the whole Figure.

10. And almost all Fields to be met with in Surveying, being bounded with a Number of unequal Lines, we first take the Plott thereof by some Instrument, and lay it down on Paper, and by drawing Diagonal Lines through it, reduce it into Triangles, &c. *Vide Fig. 10.*

11. And these Triangles or Squares, being measured by the Chain of 100 Links, when cast up, their Content is given in the lowest Denomination, (*viz.*) square Links, as in Figure 10: 10 Chains multiplied by 10 Chains, gives 100 square Chains; or, which is all one, 1000 Links by 1000 Links, gives 1.000000 square Links in the lowest Denomination, only making the Links to possess two Places of Figures after the Chains, as 6 Chains 54 Links must be written 654, without any Point of Separation between them, and 10 Chains must be written 10.00.

12. In one square Chain, there are 10000 square Links, and 100000 square Links in an Acre; the Chain therefore is divided into 100 Parts or Lengths (such as a Link is made to be) on purpose, that all Operations may be made in a decuple Manner, and to save the trouble of Division: For as the Acre is limited by Statute, this Number 100000 is the Divisor in the lowest Denomination (*viz.*) Links. So if a Field contains

1654321 square Links, we need not to find the Number of Acres therein divide it by 100000, the square Links in one Acre; but according to the old Rule, when a Divisor consisted of 1 and Cyphers, cut off from the Right-hand, so many Places of Figures of the Dividend, as the Divisor hath Cyphers, accounting them the Remainder; so shall the rest on the left Side be the Quotient; so the five last Figures cut off from the Right, there are 16 Acres for the Quotient, the remainder Parts of an Acre. Then by the known Rules in Decimal Arithmetick (*viz.*) multiplying Decimal Fractions by known Parts in the next inferior Denomination, gives those known Parts in Integers; due regard being had to the Separation. So 54321, multiplied by 4, the Roods in an Acre, produces 217284, from which Product cutting off 5 Places of Figures towards the Right, leaves 2 Roods on the left; and that Remainder so cut off, being multiplied by 40, produces 691360; and from this last Product, separating 5 Places by a Point, gives 6 Poles on the Left, and the Remainder $\frac{21}{100000} \frac{360}{100000}$ Parts of a Pole.

From what hath been said, the general Rule for casting up the Content of a Piece of Land may be given.

General Rule.

Set down the Number of Chains and Links in the Order of Multiplication, making the Links possess two Places after the Chains; and from the Product cut off by a separating Point 5 Figures to the Right-hand, so shall those on the Left be Acres: Then multiply the five Figures so cut off by 4, (the Roods in an Acre) separating five Places also from that Product towards the
Right

Right Hand; then the Figures on the left of the separating Point are Roods.

Lastly, Multiply this last Remainder by 40, (the Poles in a Rood) and separate five Places to the Right from that Product, and the Figures on the Left shew the Number of Poles.

So in *Fig. 10.* the Field $almo b$ being divided into the Triangle lmo , whose Base is 660, and the Perpendicular let fall from the Angle m , on the Base Line lo , is 252.

Therefore half 660, multiplied by whole 252; or whole 660 by half 252; or whole 660, by whole 252, then the half of this last Product is the true Content. Use any of these Methods, the Content of the Triangle lmo will be 83160.

The Diagonal Line lb divides the Trapezia $loba$ into two Triangles, lob and lba , which might be separately cast up as the Triangle lmo ; but the quicker Way is, to add the two Perpendiculars oz and ax together, and by that Sum multiply the Line lb , which is a common Base to both Triangles, and halve the half Product for the true Content of the Trapezia. See the following Work.

Base 660 — <i>l o</i> Perp. 252 — <i>m y</i> 1320 3300 1320 166320	Perp. 290 — <i>a x</i> Perp. 272 — <i>o z</i> 562 Sum Base 800 — <i>l b</i> 449600
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$$\begin{array}{r} 166320 \\ 449600 \end{array} \left. \vphantom{\begin{array}{r} 166320 \\ 449600 \end{array}} \right\} \text{Product}$$

615920 double Content.

Acres — 3.07960 true Content.

4

Roods — .31840

40

Poles — 12.73600

Acres	Roods	Poles	Parts of a Pole.
3	:	0	:
:	:	12	:
			$\frac{73600}{100000}$

The Base *l o* multiplied by the Perpendicular *m y*, produces 166320, which is double the Content of the Triangle *l m o* in square Links. Also the Perpendicular *a x*, added to the Perpendicular *o z*, makes the Sum of both 562, which multiplied by 800, the common Base to both Perpendiculars, produces 449600, which is double the Content of the Trapezia *l o b a* in square Links.

Therefore (for avoiding Fractions) the double Content of the Triangle *l m o* 166320, added to the double Content of the Trapezia *l o b a*,
449600

449600 gives 615920 the double Content of the Field *almo* in square Links, the half of which (*viz.*) 307960 is the true Content of the Field *almo* in square Links, which reduced into Acres, &c. as before directed, gives 3 Acres, 12 Poles, and a little above half a Pole, for the true Content of the Field *almo*; but the Parts of a Pole are seldom regarded.

In the same manner the Field *bcdefghiklmo*, Fig. 10. being divided into Trapezias and Triangles, add both the Perpendiculars of each Trapezia together, and by that Sum multiply the Diagonal or Base: Also multiply the Base of each Triangle by the Perpendicular, and set the Product of each Trapezia and Triangle in an orderly manner, one under another, and add them all together into one Sum, the half of which Sum is the Content of the Field in square Links, which reduce into Acres, &c. as aforesaid.

But remember to measure the Bases and Perpendiculars by the same Scale that the Plott was laid down by, and contrive to reduce the Field into as large Trapezias and Triangles as possible, for the fewer you make, the exacter will the Work be cast up; and draw the Base-lines neat and small, and exactly from Angle to Angle, and let the Perpendiculars just touch the Line, but not pass over it, at the nearest Distance from the Angle that may be; and for this End a good Pair of Compasses, and a Diagonal Scale are most proper; and the larger Scale you use the better, if the Compass of the Plott will admit thereof.

S E C T. V.

Shewing how to make the Plott of any Field or Enclosure, on the Paper on the Plain Table, by going round the same, and taking Offsets to the Bounders, &c.

Let *Fig. 11.* represent a Field to be plotted by the Plain Table.

Now the former Method of planting the Table at one Station or more, in the middle of the Field, and measuring from thence the Distance to every Angle, is easiest for a Beginner, but is not convenient in many Cases; because he may be hindred by Firze, Water, &c. from measuring the Lines to all the Angles; and in many Fields where the Fences are as irregular as the Side *a e* in this Field, he will be obliged to measure a great Number of such Lines.

'Tis therefore best to plant the Instrument at the most remarkable Angles, and measure round the Field, for by this Method, all Sorts of Land may be measured (so the Plan be not too large for one Sheet of Paper,) either within or without the Plott, as Convenience shall determine.

Note, This Mark $\odot$, always represents a Station, a Prick Line represents the Station Line, and — a Black Line the Bounder.

First set up a Mark at *a*, and draw a Line on the Table, to represent *a b*, in the Field, then measure the Distance to the Hedge from $\odot$ 20 Links, which set from $\odot$ to *f*, also measure the Distance from $\odot$ *a*, to $\odot$ *b*, 840 Links, which set on the Line *a b*.

But instead of using a Scale and Compasses, you may set on the Distance by the Plotting Scale only, such as aforementioned, whose Edge is cham-

champered, and the Numbers, and Divisions set close thereto; (being much readier than Compasses, and generally used by the best Surveyors) each Division representing a Chain, being numbered 1, 2, 3, &c. and each of those Divisions being again sub-divided into ten Parts, one of which ten Parts represents ten Links.

Therefore lay the Edge of this Plotting Scale close to the Line *a b*, the Beginning of the Numbers coinciding with *a*, and encreasing towards *b*, and because the Length of the Line *a b*, is 840, make a Mark with a Needle or protracting Pin against 840, close to the Edge of the Scale.

But if the Number had been 845, &c. you must guess at the odd Links, which you may do by a Scale of $\frac{1}{4}$ of an Inch within 2 in an Hundred, and not mistake, but with a larger Scale much nearer.

Having drawn the Line *a b*, place the Table at *b*, and lay the Edge of the Index close to the Line *a b*, and turn the Table about till you see the Mark at *a*, and there screw it fast; then turn the Line the Index about on *b*, till you see a mark at *c*, and draw *b c*, with the Point of the Compasses, or a Black-lead Pencil; also direct the Sights to the Barn, and draw the Obscure Line *b z*, not regarding its Length, so it be long enough.

When the Needle hath settled, take notice what Division in the Box it points to, for to that Division it will point at every Station through the Plott, if your Work be true, and the Needle good, as aforesaid; but because 'tis not convenient to trust to the Needle when we can do without it, I shall here lay down a surer way to correct an Error, before 'tis communicated to the following Part of the Work.

In

In the next place, Measure the Distance from $\odot b$, to the Hedge 17 Links, which set from $\odot$ to g , and draw the Bounder fg , also measure the Distance from $\odot$ to b , which set on the Paper from $\odot$ to b , and continue the Bounder fg , in a Strait Line, as you see it in the Field.

Remove the Table from b , and set up a Staff with Paper thereon in the Hole, over which the Center of the Table stood, as by former Directions, and measure from b , towards c , with the Chain, but when you come over against the Bend in the Hedge at i , measure the Distance from the Chain Line bc , to that Bend 7 Links, which set from the Chain Line bc , to i , and draw the Bounder ib , through b , till it cuts the Bounder fg , constituting that Corner of the Field.

Measure on to c , 620 Links, which set from b to c ; now the Reason why we made the Station b , so far from the Corner, is to avoid Planting the Instrument too often, for if we had continued the Station Line ab , into the Corner, we must have made another Station at i , otherwise we could not see to the Angle at c , for the fewer Stations we make, the exacter will be the Work, as aforesaid.

Now in order to examine the Length of bc , and also its Position in respect of ab , do thus: Plant the Instrument at c , and lay the Index on the Line bc , and by turning the Instrument about, direct the Sights to b , and there screw it fast; then turn about the Index on the Point c , towards the Mark at the Angle a , in the Field, and if the Edge does not cut the Point a , in the Table, the Line bc , is false, either in Position or Length, and therefore must be corrected before you proceed.

The

The Line $b\ c$, being truly laid down, and the Table standing at c , in the same Position, lay the Index to the Point c , and turn it about thereon, till the Hair in the Sights cuts the Mark at d , and draw the Line $c\ d$, also direct the Sights to the Middle of the Barn, the Index being turned about on the same Point c , and draw the Obscure Line $c\ x$, crossing the other Obscure Line $b\ z$, so shall the Point of Intersection determine the Situation of the Barn in the Middle of the Field, which you may prove by measuring on the Ground thereto, from any Part of the Field.

Next measure the Distance from the $\odot$ at c , to the Hedge 6 Links, which set from $\odot$ to k , and draw the Bounder $i\ k$, continuing the Line through k , also measure the Distance to the other Hedge $c\ d$, from $\odot\ c$, 15 Links, which set off to L .

Remove the Table from c , and place a Mark there, and measure the Distance from c to d , 481 Links, which Distance set on the Line $c\ d$, then plant the Table at d , and lay the Index on $c\ d$, and turn the Table about till you see a Mark at c , and then screw the Instrument fast.

Next, Examine the Length and Position of $c\ d$, in respect of $b\ c$, as before directed, then turning the Index about on d , direct the Sights to e , and draw the Line $d\ e$, and set off the Distance from $\odot\ d$, to the Hedge at $m\ 10$ Links, and from m , draw the Bounding Line $m\ l$, continuing it streight through l , till it crosses $i\ b$, as you see it to do it in the Field.

Leave a Mark at d , and plant the Table at e , having first measured the Length of $d\ e$, 364 Links, and set it on its proper Line from d to e , on which Line $d\ e$, lay the Index, and turning the Table about till you see the Mark at d , there screw it fast, and having proved the Line
 $d\ e$,

$d e$, to be truly laid down in respect of $c d$, turn the Index about on e , till you see the Mark at a , and draw the Line $e a$, which will cut through the Point at a , also direct the Sights to the Angle p , and draw $\odot p$, and to q , drawing $\odot q$, on the Paper.

Then measure with the Chain the Distances $\odot p$, and $\odot q$, setting those Distances on their proper Lines, and draw the Bounders $p o$, and $q p$.

Now measure on the Line $e a$, and when you come against the Bend in the Hedge at r , measure the Distance from the Chain Line $e a$, to that Bend 8 Links, which set on the Paper to r , and draw the Bounder $q r$.

In the same manner measuring on the Line $e a$, set off the Distances from the Chain Line to the Angles in the Bounders s and t , and draw the Bounders $r s$, $s t$ and $t f$, which crosses the Line $g f$, near f , and when you have measured the Line $e a$, on the Ground, you will find it of the same Length as that before drawn on the Paper.

If the Distance from the Station to the Bends in the Hedge be great, 'tis the safest way to plant the Center of the Table over the Station Line, as at w , and laying the Index on the Line $e a$, direct the Sights to e , or a , by turning the Table about, and in that Position screw it fast; then direct the Sights to the Bends in the Hedge as, to s , or t , drawing Lines towards them, and setting off the Distances in the same manner as is done from $\odot e$.

In order to examine the Lengths and Positions of each Line before you proceed on the next, if you don't think it convenient to leave Marks at all the Stations round the Field; if you turn about the Index on the Point, representing the present Station, till you see any one of the Marks before laid down, and if the Edge of the Index cuts that Point on the Paper, your Work is right;

right; so you might have left a Mark at the First Station a , and by that prove the Lengths and Positions of all the other Lines, as well as by the last but one you passed by.

But if you could not see the Mark at a , at all the other Stations, you may make use of any other Mark, as some Part of the Barn; or you may set up a Mark in some convenient Place, from whence you can see all the Angles.

But if the Mark you last us'd, is at too great a Distance from you, or lyes almost in a Strait Line with that you last laid down, then use some other Mark in its Stead, whose Position you have before found at one of the foregoing Stations.

Or instead of a Mark thus set up, you may use any remarkable Tree, Steeple, &c. that is not at too great a Distance from you, whether it be in the Land you are then Surveying or not.

How to Measure an inaccessible Distance.

Lastly, In the same manner as you found the Position of the Barn in the middle of the Field, *Fig. 11.* you may measure any other inaccessible Distance; so if the Barn was so situated that you could not come nearer thereto, by reason of Water, or other Impediments, than the Line bc , yet you would know its Distance from b , or c .

The Instrument planted at b , and the Sights directed to a Mark at c , and also to the Barn, and the Lines bz , and bc , drawn on the Paper as before directed, and the Instrument removed from b , and planted at c , and the Sights directed to a Mark left at b , and also to the Barn, and the Line cx , also drawn on the Paper, cutting the other Line bz , then shall the Point
of

of Intersection determine the Distance of the Barn from b or c , which you may find by measuring from q or c , or any other Part of the Line bc , by the same Scale with which you laid down the Line bc .

But 'tis convenient to make the Stations b and c , at such a Distance from one another, that the Angle at the Point of Intersection may not be too Acute, lest you be not able to distinguish nicely the Point of Intersection.

If *Fig. 11.* was a Wood, so that you could not measure the Station Lines within, you may as well make them on the Outside, for the Plott will be the same, only the small Pieces of Ground between the Station Lines, and Bounders, are excluded by the Bounders from being any Part of the Plott. Particular Directions in this Case are needless; *see the Figure.*

When you are about to measure a Plott of Land, and in doubt whether it will lye on one Sheet of Paper, you may place a Line or two crosse the Plott, as you walk about to choose the most convenient Stations (reckoning so many Steps to a Chain, as you find by Experience carries you a Chain's Length) and thereby guess what Scale to make use of.

Also 'tis convenient to make a particular Remark at the First Station in each Field, that you may readily find it when you come round to it again, in order to close the Plott.

Also as soon as you have drawn the Plott of a Field, 'tis necessary to write the Name somewhere in the middle thereof.

There is another Way of Plotting a Field by the Plain Table (though scarce fit for Practice) by measuring one Line only, which in short is this:

Plant the Table at a , *Fig. 12.* and direct the
Sights

Sights to the several Angles round the Field, keeping the Index close to the Point *a*, and by the Edge thereof draw a Line towards every Angle, then place a Staff at *a*, and plant the Table at the other Station *b*, measuring the Distance between the two Stations, which Distance set on the Line *a b*, lay the Index on the Line *b a*, and turn the Table about till you see the Mark at *a*, and fix there the Instrument.

Then lay the Index to the Point *b*, and turn it about thereon, directing the Sights to the several Angles round the Field as before at *a*, and towards every one of them draw a Line, which will intersect the Lines before drawn at *a*, so shall the Points of Intersection determine the Place of all the Angles round the Field, and Lines drawn from Point to Point shall give the Bounders of that Field.

But if you be not very exact and curious in drawing the Lines, and also, if the Stations are not contrived in such manner as may prevent the Lines intersecting one another at very acute Angles you may commit gross Mistakes.

And here it may be observed in this as well as any other Case of the like Nature, that all Things that are to be determined by the Intersection of Right Lines are best determined when those Lines intersect each other nearest Right Angles.

Therefore when Triangles laid down by the Length of their Sides intersecting one another with acute Angles, the Point determining where those Lines intersect, is not so well determined as it ought to be.



C H A P. II.

Shewing how to Survey any Piece of Land, by the Theodolite or Circumferentor, and to protract the same.

S E C T. I.



THE Plain Table is very useful for taking the Ground Plott of Buildings, and measuring Gardens, or small Enclosures (where the shortness of Lines, and Multiplicity of Angles would be apt to breed Confusion in protracting,) but by no means fit for surveying large Tracts of Land, because the least Moisture, or Dampness in the Air, makes the Paper not only sink, but run up when dry'd again, and thereby the Lines drawn thereon are disorder'd, making the Content less than it should be; and in the least Rain or Mist, the Instrument becomes altogether useles; also, when the Plott proves larger than will lye on one Sheet of Paper, there must more be pieced thereto with Glue or Paste, which wetting only some Parts of the Paper, is liable to the aforesaid Inconveniencies, neither can several Sheets of
Paper

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Paper be joyn'd together after the Plott is drawn thereon, so as to meet exactly, and lye so flat as it ought to do; and if to these Inconveniences be added the tediousness of compleating the whole Plott in the Field, when a Surveyor has his Assistants about him, that alone might be Objection enough to induce any Person to make use of fitter Instruments.

Here follows the Description and Uses of a New Theodolite, being the most absolute Instrument yet invented for Surveying Land.

If we be not very exact and curious in measuring the Angles in the Field, the Plott on the Paper can never be truly laid down; and if the Instrument with which we measure these Angles be not well fram'd and divided, all the care we can take in making the Observations in the Field will be to little purpose; therefore, I thought it might not be improper first of all, to give a general Description of a new Theodolite, which hath met with a general Applause from all Mathematicians that have seen it, and far exceeds any other Instrument that hath yet been invented.

For the Ball and Socket is so contriv'd, that the whole Instrument may be set as truly Horizontal, as by the help of any Rack, and with less than a tenth Part of the Trouble and Time, and this in measuring every Angle is absolutely necessary; for Instance, suppose we were to measure an Angle on the side of an Hill, by one of the Theodolites as commonly made, and had set the Instrument as near a level as we could by the Eye, and then proceeded to make an Ob-

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servation;

lervation; if then the Limb be out of the Horizon, suppose but two Degrees; (and it can scarce be set nearer if so near, for the Ground being on a Declivity will deceive us) the Angle thus measured will be considerably false; for the Instrument thus planted on the side of the Hill, let the Telescope be directed to the first Object, and that part of the Limb next your Eye fixed two Degrees out of the Horizon, and then let the Telescope or Sights be turn'd round to the other Object, and elevated thereto, suppose ten Degrees; then the Index will cut on the Limb, the Number expressing the Angle, suppose ninety Degrees; now this Angle of ninety Degrees is measured above twenty one Minutes false, and if the Lines that form the Angle, happen to be long, this Error will be very considerable in regard of the true Content of that Piece of Land, and the Plott can never be expected to close, if the Angles be thus measured; but in the use of this Theodolite, this Inconvenience is remedied, the Instrument being so easily set exactly Horizontal.

There is a Quadrant nearly, the Radius of the Instrument so fix'd over the Center, as to move exactly in a vertical Circle, within which is a Spirit level, and over that the Telescope fix'd thereto, so contriv'd that when the Bubble rests in the middle of the Spirit-tube, the Horizontal Hair in the Telescope will cut an exact Level, and by its Motion in a vertical Circle, whatever Object this Hair cuts above or below, the true Level, its Elevation or Depression will appear by the said Quadrant divided and grav'd for that Purpose; there is also in the Telescope a vertical Hair to be us'd in the measuring Horizontal Angles, so that both the Horizontal and vertical Angles are observ'd at the same time, which is extream Useful in laying down the

the Plotts when the Hynothenusal are to be reduc'd to horizontal Lines.

This Instrument is well contriv'd for working with the Needle only; for as soon as the Instrument is set steady on the Ground; the Needle will lye in the direction of the magnetick Meridian, and there be at rest; and then the Point in the Box mark'd with 360, may be brought to the north End of the Needle, and there fix'd without stirring the Needle; also the Index and Telescope may be mov'd round to any Object in the same Manner; for the Head of the Staff is made of Brass, and not liable to shake as the wooden ones are, which contributes much to the true measuring of an Angle, and the Index is mov'd round a conical Center, touching the Limb in three Places at 120 Degrees Distance, and if by much wearing it should shake, that is instantly help'd by a Screw for that Purpose; for if the Index grows loose and shakes, it will not cut the Minutes on the Limb to any Exactness.

The Pin, on which the Needle hangs, is made of temper'd Steel turn'd and polish'd in the Lath, and may be taken out and put in at Pleasure, and is not screw'd to the Box, but remains fix'd always in the same Position, whilst the Box, Index, and Telescope are mov'd round it, and the Telescope fix'd to an Object without stirring the Needle, so that an Observation may be made both by the Limb and Needle at the same Instant.

And when the Telescope is directed to an Object, the whole Instrument is fix'd there in so firm a Manner, with small Power, that the Motion of the Index when the Telescope is directed to the next, shall not move the Limb from the Position in which it was first fix'd; which in other Theodolites is very difficult to be done.

The whole Instrument is made very portable, and the Uses thereof plain and simple ; one Telescope being apply'd to all the Operations, neither is any thing to be added or taken from it when we make use thereof.

Being thus provided with a good Theodolite ; we now proceed to shew the Manner of using it in measuring Land.

The most material Things to be done in the Field are two ; First, to measure the Length of the Lines ; and Secondly, the Quantity of the Angles.

The manner of measuring Lines in the Field is already laid down ; we now proceed to the Angles.

S E C T. II.

The Description of an Angle.

An Angle is the meeting of the two Lines in a Point ; provided the two Lines so meeting don't make one strait Line, as the Lines a, o , and x, o , *Fig. 12.* meeting together in the Point o , form the Angle a, o, x .

Angles are measured by the Arch of a Circle describ'd from the angular Point as a Center ; so the Angle a, o, x , is measur'd by the Arch of the Circle, *Fig. 13.* describ'd from the angular Point o : The Arch of this Circle that measures the Angle a, o, x , being intercepted between the Lines a, o , and $x o$.

An Angle is said to be equal to, greater or less than another, according as the Arch which measures it contains as many more, or fewer of the equal Parts into which the Circle is suppos'd to be divided.

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The Circle is divided into 360 Parts or Degrees, and each Degree into 60 other Parts call'd Minutes; or suppos'd to be so divided, so that any Portion of the Circumference is express'd by the Number of Degrees and Minutes it contains.

'Tis no matter whether the Circle be great or small, for each is suppos'd to contain 360 Degrees (except that the Minutes are better estimated on a great Circle than a small.)

The Line $o b$, is the Radius of the Circle, *Fig. 13.* z, d , is the Diameter, and passes through the Center o , dividing the Circle into two equal Parts; the Line $z e$, is the Chord of 60 Degrees joining the Extremities of the Arch $z e$.

$Z o b$, is a Right angled Triangle, $z o$ the Base, $o b$ the Perpendicular, and $b z$ the Hypotenusal. Then the Angle $z o b$, contains 90 Degrees, which is the Measure of a right Angle.

$A o x$, is an acute Angle, containing less than 90 Degrees.

$A o y$, is an Obtuse Angle containing more than 90 Degrees,

'Tis no matter of what Length the Lines of an Angle be; 'tis their meeting one another in a Point that forms the Angle, for the Angle $z o b$, contains 90 Degrees, and $a o c$, contains 90 Degrees also.

Let the Circle *Fig. 13.* represent the Limb of the Theodolite, and let the Index be brought to the beginning of the Numbers at z , then the Telescope which moves therewith, will be set in the Direction of $o a$: Now move the Telescope till it be in the Direction of $o x$, so shall the Index on the Limb shew the Number of Degrees of the Angle $a o x$.

Let $x o$, and $o y$, represent two Station Lines in the Field, then the Center of the Theodolite being planted over the angular Point o ,

let the Telescope be directed to x , (the Index being brought to the beginning of the Numbers on the Limb at o) and the Instrument fix'd there: Now move the Telescope till you see y , so shall the Index shew the Quality of an Angle x, o, y , on the Limb, 119 Degrees.

In working with the Theodolite we only measure the Length of the Lines, and Quantity of the Angles in the Field, which we note in a Field-Book for that Purpose; and by these Directions we may draw the exact Plan of the Land, which is call'd Protracting.

Provide a Field-Book rul'd with three Columns, in the middle Column insert the Quantity of the Angles, and Length of the Station Lines; in the outer Columns the Offsets from the Station Lines to the Bounders, and on each Side note the Remarks which you meet with in the Survey.

S E C T. III.

Shewing the Uses of the Theodolite in measuring the Angles round any Field or other Piece of Land.

The Theodolite before mention'd is numbred on the Limb, from the Left to the Right; and the Box from the Right to the Left; and therefore the Circuit is most conveniently made (according to the common Phrase) *contra solem*. i.e. with the Fences on the right Hand.

Let Fig. 14. represent a Field of which a Plott is desired: First, chuse some convenient Place therein, to begin the Work as at $\odot$, near the Corner of the Field a , and set up a Staff with a Mark thereon, as a Piece of Paper, or a
white

white Rag, so that you may plainly see it at the next Station; then lay the Chain in a straight Line from *a* towards *b*, having first set up a Staff at *b*.

The Chain lying in this Direction on the Ground, measure with the Offset Staff from *e*, the Distance to the Hedge 56 Links, and enter in the middle Column of the Field Book *e*, and in the right Hand Column 56, denoting an Offset laid off from *e*, 56 Links to the right Hand of the Station Line.

Measure forwards on the Station Line *a b*, till you come against the next Bend in the Hedge, then let the Chain lye on the Ground in a right Line between the Stations *a*, and *b*, and with the Offset Staff, measure the Distance from the Chain to that Bend in the Hedge 140 Links.

Take notice at what Length of the Station Line each Offset is laid off; as here at the Length of 540 Links on the Station Line, I lay off an Offset of 140 Links, therefore in the middle Column of the Field-Book that represents the Station Line enter 540, and against it in the Column on the right Hand, write 140, denoting that at the Length of 5 Chains 40 Links in the Station Line, you laid off an Offset to the right 140 Links.

Also take Notice that these Offsets are to be measured from the Station Line to the Hedge or Bounder, in such Manner that the Line representing the Offset may stand at right Angles with the Chain or Station Line, as the Line *o c*, with *z d*. *Fig. 13.*

Here I would advise a young Beginner in this Art, not only to enter these Observations in the Field-Book, but also on a Piece of waste Paper, to draw first a Line that shall represent the present Station Line, and then upon that, to set off the

the Offsets as he measures them in the Field, drawing the Bounders as he goes along, not regarding the Length of any Line, a resemblance of each Line being sufficient; because the true Lengths are entered in the Field-Book; for laying this Sketch before him, when he protracts his Work, he will find it an useful Instruction, in drawing his Angles inward or outward, and laying the Corners of the Field in their true Position, with other little Difficulties to be met with in Practice; but when he is accusom'd to a right Method of keeping the Field-Book this Trouble will be spar'd.

I proceed to measure on the Station Line to the next Bend in the Hedge, and there lay of an Offset at 8 Chain 26 Links, therefore against 826 in the middle Column of the Field-Book; write in the next Column on the Right; 36 Links the Length of the Offset.

The Hedge continuing streight to $\odot$ 2, measure up thereto, and enter the Length in the Field Book 1120, and measure the Distance to the Hedge 36 Links, which enter in the Column of Offsets against 1120, and draw a Line cross the Field-Book.

Now remove the Staff from *b*, and cause it to be set up in a convenient Place, as at *c*, then plant the Center of the Theodolite exactly over the Hole, in which the Staff stood at *b*, by the help of the String and Plummet, as directed in the Use of the plain Table, making the Staves of the Instrument to stand firm on the Ground, then bring the Index to 360 on the Limb, and turn the whole Instrument about till the Hair in the Sights cuts the Staff at *a*, and there Screw it fast, that the Motion of the Index may not cause it to stirr from this Position; then turn the Index about till the Hair in the Telescope cuts

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cuts the Staff at c , so shall the Index shew the Quantity of that Angle $a b c$, on the Limb, viz. 102 Degrees 20 Minutes, which note in the Field-Book for the Quantity of that Angle.

Now for certainty that you have measured this Angle Right, you may turn the Telescope back to the Staff at a , and if the Hair cuts it you are right, otherwise not.

Having measured this Angle, let the Staff be brought from a , and place it in the Hole, over which the Center of the Instrument was posited at b , but leave some Remark at a , that you may find it again when you come round the Field to close the Plott: and lay the Chain from b , towards c , and at $\odot$, measure the Offset to the Hedge 20 Links, at 236, in the Station Line, I lay of the Offset 36, at 428 in the Station Line, the Offset is 92, and at 796 the End of the Line, the Offset is 30, to the Corner, therefore against 30 in the Column of Offsets, write Corner, denoting that Offset laid of at Right Angles from the Station Line, reach'd the Corner of the Hedge.

Place the Instrument at c , and as before directed, measure the Angle $b c d$ 110 Degrees 40 Minutes, which note in the Field Book for the Quantity of the Angle at c .

When you have measured the Angles, and made the necessary Observations at each Station draw a Line cross the Field Book as you will see in the Form thereof, also take notice that the Minutes are estimated by the help of *Nonus's* Invention which can't be so well describ'd as by the Sight of the Instrument; only this may be said, that we can thereby estimate the Quantity of an Angle to 2 or 3 Minutes, which is as exact

exact as they can be laid down on Paper by the Protractor.

Bring the Staff from *b*, and set it as upright as you can at *c*, and send another forwards to *d*, then measure on the Line *c d*, and lay off the Offset to the Corner at 434, and against that Offset write Corner in the Field-Book, and measure up to *d*, entering the Length 468 in the Field-Book.

Plant the Instrument at *d*, and bring the Index to 360 on the Limb, and turn it about till the Hair in the Telescope cuts the Staff at *c*, and there fix the Instrument, and then direct the Telescope to *e*, and note the Quantity of the Angle at *d*, which the Index cuts on the Limb, viz. 230 Degrees 50 Minutes, which note in the Field-Book for the Quantity of that Angle.

But no Angle is greater than 180 Degrees, therefore if you would know the true Quantity of this Angle, subtract 230 Degrees, 50 Minutes, from 360 Degrees, the Remainder is 129 Degrees 10 Minutes, the true Quantity of that Angle.

Note, When you meet with an outward Angle, remember to Mark it in the Field-Book with $\succ$, or some such Mark, as a Direction when you come to protract this Angle; to draw it outwards as it is in the Field.

In the same Manner deal with the rest of the Lines and Angles round the Field, till you come to Station *a*, but there is no necessity to measure the last Angle, or the two last Lines, unless it be to prove the Truth of the Work, which indeed is convenient.

When the Instrument was planted at *f*, and you had measured the Quantity of that Angle, the Instrument remaining in the same Position, if you direct the Telescope to the Tree

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in the Middle of the Field, and note the Degrees, &c. which the Index cuts on the Limb, and the same at *g*, and note these Degrees, &c. in the Field-Book, in the Column of Remarks, you may protract the true Situation of the Tree in respect of any other Part of the Field.

See the Form of these Observations as noted in the Field-Book.

The

The Field-Book.

Remarks	Offsets	Station Lines	Offsets	Remarks
		$a \odot 1$		

		0	56	
		540	140	
		826	36	
		1120	36	
		$b \odot 2$		
		0		
Angle		102.20		

		0	20	
		236	36	
		428	92	
		796	30	Corner
		$c \odot 3$		
		0		
Angle		110.40		

		434	30	Corner
		468		
		$d \odot 4$		
		0		
Angle >		230.50		

		420	30	

The Field-Book Continued.

Remarks	Offsets	Station Lines	Offsets	Remarks
		e @ 5		
	Angle	79.00		
		0	40	
		134	36	
		296	33	
		588	100	
		820	12	
A Tree bears from @ 6	Angle	f @ 6		
38.30		84.30		
		40	120	Corner
		200	24	
		706	16	Corner
Tree bears from @ 7	Angle >	g @ 7		
57.30		233		
		380	80	
		648	40	

S E C T. IV.

The next Thing to be done, is to protract the Observations made in the Field, *Fig. 14.* so that the several Lines and Angles therein, may be laid down

down on Paper of the same Length, and in the same Direction as in the Field it self. In proportion as the Scale we make use of is to the Chain.

The Protractor generally used, is a Semicircle, though a whole Circle is better. Numbred and divided in the same manner as the Limb of the Theodolite, which it should always be; the Protractor being esteem'd an Epitome of Instruments.

But because the Degrees on the Protractor, are so much smaller than those on the Limb of the Theodolite, they can't be well estimated nearer than 10 Minutes; yet if any one will be curious, he may lay down the Angles on the Paper, to a Minute or two as exactly as they can be observed in the Field.

Mr. *Ward's* Protractor being commonly used for this Purpose, is made with an Index to move on the Center of the Semicircle, which Index is divided into 2 Parts, so fram'd, that each may be the Diagonal of one Degree; so that if the distance at the extream Ends be 10 Degrees, that next the Limb must be 8 Degrees, the Space between the two Limits in each Diagonal being divided into 60 Parts or Minutes; but these Divisions will be very unequal, being those of the Tangent Line, which fall near Infinite.

Mr. *Siffon* hath removed this Inconveniency, by making each Edge the Arch of a great Circle passing through the Center of the Protractor; the Space between the first and last Divisions being two Degrees thereof, and is divided into 60 equal Parts or Minutes.

The Reason depends on the 27 *Prop.* of the 3^d, of *Euclid*, viz. That the Angle at the Center of a Circle is double to that at the Circumference.

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The same Person hath contrived another Protractor, to lay down Minutes without any Index at all, and therefore preferable to both the former, because 'tis exceeding difficult to make the Index move exactly round the Center, and if it shakes the least that can be, the Instrument is useless; but this last is made of one Piece of Brals, and may be us'd as a common one, without regarding the Minutes when Expedition is requisite.

It may be thought here are too many Words spent about describing these Protractors as well as the Theodolite before mentioned; but if any one pleases to consider, that if we be not very exact in measuring the Angles in the Field, and laying them down in the same manner on Paper, (which is impossible to be done without good Instruments) we shall commit very great Mistakes; for Instance, If I mistake half a Degree in the measuring of an Angle, one of whose Sides is 20 Chains, the Area or Content of that Piece of Ground so left out or added to the Plott, by drawing this Line in a false Position, will be above 23 Poles; and this Error communicated to the following Work, will be very considerable in the whole.

S E C T. V.

The Manner of Protracting the foregoing Observations.

AS the Lines are measured in the Field by the Chain, and the Angles by the Limb of the Theodolite, so the Lines are laid down on the Paper by the Scale, and the Angles by the Protractor.

Provide a Skin of Parchment, if the Plott is desired to be on Parchment, according to the
E
large-

largeness of the Work you are about to lay down; or if on Paper, let it be large enough to hold all your Work; the strong Cartridge Paper for this Purpose is accounted best by some Surveyors.

Having considered which way the Plott will extend, draw an obscure Line on the Paper to represent the first Station Line, and mark the End thereof with $\odot a$, so shall that Point represent the first Station in the Field, and close to this obscure Line, lay the edge of your plotting Scale, the beginning of the Numbers coinciding with $\odot a$, and encreasing towards the next Station; then lay the Field-Book open before you, and because the offsets in the first Length are taken at the Distances 0, 540, 826, 1120; therefore against these Numbers on the Scale, make Marks in the obscure Line, close to the edge of the Scale.

This done, turn the Scale perpendicular to the obscure Line, so that the several offsets may stand thereon at right Angles as aforesaid, and apply it successively to these several Points, and there Prick off the Length of the several offsets on the same Side of the obscure Line as noted in the Field-Book; so at $\odot I$ prick off 56 at 500, the next Length I prick off 140, at the next Point, which is at the Length 826, I prick off 36, and at 1120 the End of the Line, I prick off 36.

Now if Lines are drawn from Point to Point, they shall represent the Bounders of this Side of the Field; and because the Hedges, especially in old Enclosures, are generally in the Form of a curve rather than strait Lines, therefore if you draw the Bounders from Point to Point with a Quill-Pen with your Hand only, they will be more naturally express'd, than if you lay a strait Ruler from Point to Point, (except the Distances

ces are very long, or you take a multitude of Offsets;) and to be exact, 'tis sometimes necessary to express the Nature of these little Irregularities in the Fences, by a Sketch on one Side of the Field-Book; but if you will be very curious, you may have an Instrument in Form of a Steel-Bow, which by the help of Screws may be drawn in any curve Form, and by this the Bounders may be readily drawn.

The Length of the first Station Line being 1120, mark that Distance from $\odot a$, with $\odot b$, and let the obscure Line be produc'd, each way as long as the Radius of the Protractor.

Lay the Center of the Protractor to the Point $\odot b$, and turn it about thereon, till the Diameter lyes on the Line $\odot a$, $\odot b$, the beginning of the Numbers on the Protractor being laid towards $\odot a$, contrary to the Theodolite in the Field.

Hold the Protractor close down to the Paper in this Position, and because the Angle at b , is 102 Degrees 20 Minutes, therefore with a Protracting Pin or Needle, make a Mark against 102 Degrees 20 Minutes, close to the Limb of the Protractor, through which Mark from b , draw the obscure Line $b c$.

So is the Station Line $b c$, laid down in the same Direction as in the Field, and the Angle $a b c$, the same.

Lay the Plotting Scale to the obscure Line $b c$, the beginning of the Numbers coinciding with the present Station, and the Numbers encreasing towards the next, then close to the edge thereof, against c , 236, 488, 796, the Lengths where the Offsets were taken, make Marks with the Protracting Pin, and turn the Scale perpendicular to the obscure Line, and Prick off the several Offsets, 20, 36, 92, 30.

And now if Lines are continued from the Fences before drawn to these Offsets, they shall represent the Bounders on this Side of the Field.

The Offset at the End of the second Station Line, at *c*, reaches into the Corner, but those at *b* must be continued till they meet one another, and this might be expressed in the Field-Book or Sketch, that you may not mistake the Corner of the Field.

Lay the Center of the Protractor to *c* the Diameter, held close to the Line *b c*, and against 110 Degrees 40 Minutes on the Limb of the Protractor, make a Mark, through which draw the Line *c d*.

At the Length 434, in this Line lay off the Offset 30 Links, to which continue the Bounders before drawn, so is this Side of the Field finished.

Note, the next Angle at *d*, being noted in the Field Book, 230 Degrees 50 Minutes, you must either subtract $2^{\circ}30'50''$, from $3^{\circ}60':00''$ the Remainder is, 129 Degrees 10 Minutes for the true Quantity of that Angle; and because 'tis marked External, it must be plotted outward, and the beginning of the Numbers on the Protractor must be laid the contrary way, *viz.* towards the next Station.

Or if the Protractor be numbred to 360, on a Circle concentric to the outward Circle, and the Numbers on both encrease the same way, (as the Limb of the Theodolite) then the Angle 230 Degrees 50 Minutes, may be pricked off from the inner Circle.

But if you use a circular Protractor, it may be laid always one way, *viz.* the beginning of the Numbers towards the last Station, contrary to the Theodolite in the Field, and this in my Opinion is the best Way.

But

But if you use a semicircular Protractor, observe to lay the Diameter on that Line which brought you to the present Station, and to lay the beginning of the Degrees of the Protractor towards the last Station when the Angle is less than 180 Degrees, but the contrary way when the Angle is more.

So at *d*, lay the Diameter of the Protractor on the Line *c d*, the beginning of the Numbers being laid the contrary way to *c*, and against 230 Degrees 50 Minutes on the inner Circle of the Protractor, make a Mark, through which draw the Line *d e*.

In the same manner lay down the Angle at *e*, and draw the Line *e f*, continuing the Bounders as before directed.

When you have marked the Angle at *f*, let the Protractor lye in the same Position, and make a Mark against 38 Degrees 30 Minutes, as noted in the Field-Book for the bearing of the Tree from that Station, and through that Mark draw an obscure Line from *f*.

Do the same at *g*, continuing the obscure Line from thence till it crosses that drawn from *f*, so shall the Intersection of these two Lines determine the Situation of the Tree in the Middle of the Field.

In the same manner may any other inaccessible Distance be measured by the Theodolite.

When you have Marked the Angle at *g*, and drawn the Line *g a*, it will cut through the Point *a*, and the Length of the Line *g a*, will be the same as that noted in the Field-Book, and the Angles at *g*, and *a*, (if you had measured it) the same which proves the Plott to be truly laid down.

S E C T. VI.

IT may not be improper to take notice in this Place, of the Method proposed by some Authors, as a Proof that the several Angles in a Field are truly measured, by collecting the Quantities of all the Angles into one Sum, and then to multiply 180, by a Number less by two than the Number of the Angles in the Field; and if the Product of this Multiplication be equal to the total Sum of the Angles, the Work is concluded to be right.

But these two Numbers may agree, and yet a Mistake may be committed in measuring the Angles; as for Instance:

Let the Number of Angles in the Field be 7, and the Quantities collected into one Sum be 900; then multiplying 180, by a Number less by two than the Number of the Angles, *viz.* 5, the Product is 900, equal to the Sum of the Angles.

Let the true Quantity of the first Angle be 160 Degrees, and the true Quantity of the Second 190 Degrees; these two Numbers when added together make 350; but suppose you had made a Mistake in estimating the Degrees on the Instrument, or noting them in the Field Book, and for the First Angle had noted 190 Degrees, and for the Second 160 Degrees, their Sum will still be 350; so that by this Method you will not discover your Error; but hereafter will be inserted a Method, whereby an Error may be corrected at every Station in the Field before we leave it by the help of the Needle and Limb together, but first I proceed to shew the Use of the Needle only in surveying Land.

S E C T.

S E C T. VII.

Of the Circumferentor.

THE Circumferentor is an Instrument used to measure Angles in the Field ; it consists of a Box and Needle, screwed to the Index with plain Sights thereon, or instead of the plain Sights with a Telescope mounted over the Box, that may be either elevated or depressed to an Object as there shall be occasion ; the Index is mov'd by a Ball and Socket, and supported by a three legged Staff.

In Surveying Harbours, Seacoasts, Counties or large Commons, where the Lines are very long, or thick over grown Woods, where we may be forced to make a multitude of Angles, and the Sight of the two Lines constructing the Angle, may be hindred by the Brush or Underwood ; in these Cases the Angles may be measured sufficiently exact by the Needle only, (though better, and as quick by the Theodolite, as will be shew'd hereafter) yet in surveying Lordships, Enclosures, or plain Pasture Land, (a small piece of which got or lost is of a considerable Value, and each particular Field ought to close exactly) the Angles are without doubt more surely measured by the Limb of the Theodolite, because the Degrees in the Box can't be so nearly estimated, and the Needle is liable to be drawn aside by some hidden magnetick Power.

The Position or bearing of a Line observ'd by the Needle, is expressed by such a Number of Degrees and Minutes as it is distant from, or Quantity of the Angle, which that Line makes with the Meridian.

And if a Person wholly unacquainted with the use of this Instrument, will take the Pains to try this following Method, it may be an help to conceive the manner of using it in the Field.

Upon a Sheet of Paper let there be drawn right Lines parallel one to another at any Distance, and upon a Table let there be fixed a Pin with the Point upwards, let the Pin so fixed, be run through one of the Lines in the Paper, and upon the Point of the Pin, let there be put a Magnetick Needle, let it traverse about till it rests of it self; then turn the Paper about on the Table till the Needle hangs directly over the Line, in which the Pin is placed, which is discovered by fixing the Eye over its center; then with sealing Wax fasten the Paper to the Table by the four Corners; so may the Paper be supposed to represent the Surface of the Earth, and the Lines the magnetick Meridian (which mark at the top with North, and at the bottom with South.)

For if the Pin be removed into any other of the Lines, and the Needle be made to traverse thereon, it will, when at rest, hang directly over the Line in which the Pin is placed, if it be drawn parallel to the first Line, over which the Needle hung when the Paper was fixed.

The Needle then points always to or lyes in the direction of the Meridian, by virtue of the magnetick Power; so if I had fastened to the Table a Sheet of blank Paper, and had laid a Ruler in the same direction with the Needle when at rest, and had drawn a meridian Line, and removed the Needle to another part of the blank Paper, and drawn another such a Line by the direction of the Needle, that would have been a Parallel,

When

When we take an Angle in the Field by the Needle, the meridian Line is always one side of the Angle, and the Hedge Wall or Fence along which the Telescope is directed, is the other side of the Angle, and they are supposed to meet at the Center of the Instrument.

But with the Theodolite, the Angle is formed by the meeting of the two Lines or Fences themselves.

Set one Foot of a Pair of Compasses in some one of the Meridians on the Paper, and describe a Circle, then the Line is its Diameter: Divide this Circle into 360 Degrees, which is easily done by the Protractor, and let the Numbers begin at N. or North, and encrease to the left, towards E or East.

Then this Circle represents the Box of the Instrument in the Field, and the Line N. S. represents the Needle.

From the Center of the Circle, draw a long Line any way at a venture, and imagine this Line represents an Hedge or Station-Line in the Field, and to find its bearing or Angle that it makes with the meridian, look what Degreee, &c. it cuts on the Circle, for that is the Quantity of the Angle or Number, expressing its bearing, counted from the beginning of the Numbers.

So the Needle used in the Field points out the magnetick Meridian, and the Divisions in the Box mov'd under it measure the Angle, that any Line in the Field makes with that Meridian.

The Box of the Circumferentor is commonly numbred from the right to the left; the Numbers beginning at N or North, which is mark'd also with a Flower de luce, and encrease towards E or East, and the direction is to be taken from the North end of the Needle.

Let it be required to observe the bearing of the several Station-Lines that encompass the Wood,

Fig. 15.

SECT.

S E C T. VIII.

The Use of the Circumferentor in Surveying Land.

First plant the Circumferentor at some convenient Station as at *a*; the Flower de luce in the Box being from you, direct the Sights to a Mark at the next Station *b*, and mark the Division which the North end of the Needle points to in the Box when at rest, which is 260 Degrees 30 Minutes; therefore note this Number 260 Degrees 30 Minutes in the Field-Book, for the bearing of the Line *a b*.

Observing former Directions for removing the Instrument from one Station to another, and measuring the Station-Lines and Offsets from thence to the Bounders as you pass along the Station-Lines, let the Instrument be removed from *a*, and planted at *b*, the next Station; then keeping the Flower de luce in the Box from you; turn the Instrument about till the Hair in the Sights cuts a Mark at the next Station *c*; then will the North end of the Needle point to 292 Degrees 12 Minutes, which note in the Field-Book for the bearing of the Line *b c*.

The Instrument planted at *c*, and the Sights directed to *d*, the bearing of that Line *c d* will be 331 Degrees 45 Minutes.

In the same manner proceed to take the bearing of the other Lines round the Wood, observing this general Law.

To keep the Flower de luce in the Box from you, and to take the bearing of each Line from the North end of the Needle.

The Numbers in the Card of some of these Circumferentors are made to encrease towards the right, but that before mentioned is best; for when

when you turn your Instrument to the Eastward, the Needle will hang over the Westward Division on the contrary Side.

Instead of planting the Circumferentor at every Station in the Field, the Bearings of the several Lines may be taken if it be planted only at every other Station.

So if the Instrument had been planted at *b*, and the Flower de luce in the Box kept towards you when you look back to the Station *a*, and from you when you look forwards to the Station *c*, the Bearings of the Lines *a b*, and *b c*, would be the same as before observed; also the Bearings of the Lines *c d*, and *d e*, might be observed at *d*, and *e f*, and *f a*, at *f*; so that instead of planting the Instrument 6 times, you need in this case plant it but 3 times, which saves some Labour.

But since you must go along every Station Line, to measure it or see it measured, the trouble of setting down the Instrument is not very great, and then also you may examine the Bearing of each Line as you go along; and if you suspect an Error in the Work by the Needles being acted on by some hidden magnetick Power, or from your own Mistake, in observing the Degrees that the Needle points to, you may correct such Error at the next Station before you proceed.

As when the Instrument was planted at *a*, and the Sights directed to *b*, the Flower de luce from you, the North end of the Needle pointed to 260 Degrees 30 Minutes; now being come to *b*, direct the Sights back to a Mark at *a*, keeping the Flower-de-luce towards you: So shall the North end of the Needle Point to 260 Degrees, 30 Minutes, as before at *a*, and then you may be sure the bearing of the Line *a b*, is truly observed.

But if the Needle doth not point to the same number of Degrees, &c. there hath been some Error

Error in that Observation, which must be corrected before you proceed.

If you have a suspicion that the Needle doth not play well, when the Instrument is planted at any Station, as at *a*, direct the Sights to the Mark at *b*, and note the Degrees, &c. pointed at by the Needle in a piece of waste Paper; then with a clean Knife, Key, or any bit of polish'd Steel, that hath touched a Loadstone, move the Needle by applying it to the Box, and examine when it hath settled again what Degrees it then Points at, the Sights being still directed to the preceding Mark at *b*; and if the Degrees are the same, they may be entred in the Field-Book, but if not, the Cap and Pin must be cleansed with some brown Paper and a little Putty, and thereby freed from such Dust or Dampness that hath gotten to it; if after all the Needle does not play freely, place in the Box another Pin, or use another Needle, or do both, and these Necessaries a Surveyor ought to have in his Pocket while he is in the Field.

If you would measure the Quantity of any Angle by the Needle, place the Instrument at the angular Point, and take the Bearing of the two Lines constructing that Angle, and subtracting the lesser out of the greater, the Remainder is the Quantity of that Angle, if less than 180 Degrees, but if the Remainder is greater than 180 Degrees, subtract it out of 360 Degrees, and that last Remainder is the Angle.

The manner of entring the Offsets in the Field-Book, is before shewn in the use of the Theodolite; it will be sufficient in this place, to insert the Bearing of each Line or Quantity of the Angle, which each makes with the Meridian, together with their Lengths, in order to protract or lay them down on the Paper Plott of the same

same Length and in the same Direction as in the Field. *Vide Fig. 15.*

S E C T. IX.

The manner of Protracting the foregoing Observations made by the Circumferentor.

Lines	Bearings	Links	
<i>a b,</i>	260	30—	1242
<i>b c,</i>	292	12—	1012
<i>c d,</i>	331	45—	1050
<i>d e,</i>	59	00—	1428
<i>e f,</i>	112	15—	645
<i>f a,</i>	151	30—	1806

First, draw Lines parallel to one another quite through the designed Draught, at Distances not exceeding the Breadth of the diametrical Part of your

Protractor, as in *Fig. 15*, and mark them with N, and S, for North and South; then considering which way the Plott will extend, assign a Point in some one of the parallel Lines, to represent the first Station in the Field, as at *a*, to which Point lay the Center of the Protractor, and by the help of the Divisions continued beyond the Ends of the Diameter of the Protractor, lay the Diameter upon, or parallel to those North and South Lines; the beginning of the Numbers on the Protractor towards that part of the Line mark'd with N, or Northwards, when the Degrees are fewer than 180, but Southwards when more; the Protractor thus placed, look in the Field-Book for the Bearing of the first Line *a b*, which is 260 Degrees 30 Minutes; therefore with the beginning of the Numbers on the Protractor towards *s*, close to the Limb against 260 Degrees 30 Minutes make a Mark, and through

through that Mark from the assigned Point at *a*, draw a Line *a b*, on which Line set 12 Chains 42 Links, as noted in the Field-Book.

So will the Line *a b*, on the Paper, have a Bearing like to that, which you observed the Line *a b* to have in the Field, in respect of the Meridian, but the Protractor to lay down these Observations must be numbred contrary to the Box of the Circumferator; and if it be a Semicircle it must be numbred, first to 180, and then on the inner Circle whose Numbers must encrease the same way as the outer Circle to 360, and the Bearings greater than 180, are pricked off from this inner Circle, and the beginning of the Numbers must be laid Northward or Southward as the Degrees of Bearing are more or less than 180; but if your Protractor be a whole Circle, the beginning of the Numbers may be kept always one way, as the Numbers of the Circumferator were in the Field, (the Protractor being an Epitome of the Instrument you make use of in the Field) but the Diameter must be always laid upon a Parallel to the meridian Lines, and may be mark'd with N S at the Ends as a Direction to keep it in its true Position.

Having made the Line *a b* of its true Length and Position, the next thing to be done is to lay off the Offsets therefrom, which gives the Bounders of that side of the Wood, *Fig. 15.*

Lay the Center of the Protractor to the Point *b*, and because the Bearing of the Line *b c*, is more than 180, lay the beginning of the Numbers of the Semicircular Protractor towards S, and against 292 Degrees 12 Minutes, make a Mark, through which Mark from *b*, draw the Line *b c*, setting off the Offsets therefrom, and draw the Bounders of that side of the Wood.

In

In the same manner lay down the other Lines cd , de , ef , and fa ; so will the Line fa , cut through the Point a , and be of the same Length on the Plot as that measured in the Field, if the Observations be truly made.

Then if you drew the Station-Lines, and Offsets with a black-lead Pencil, and the Bounders with Ink; you may with a piece of Bread rub off those Lines, so shall the true Bounders of the Wood only remain, which gives the exact Figure thereof.

S E C T. X.

The manner of casting up the small irregular Pieces of Ground, which lye between the Station Lines and Hedges.

IT very rarely happens that the sides of a Field are all strait Lines, and therefore any Method for measuring them from one or more Stations in the Middle, can seldom be put in Practice; the best way being to go round, and measure the several Angles from Stations near the Bounders, but at such a Distance from thence that we may see clearly from one Station to another, and have plain Ground to measure the Distances, free from the Incumbrance of brushwood, Trees, &c. so shall the greatest Quantity of the Land be included between the regular Station-Lines, which is cast up as before directed by dividing the same into the largest Trapezias and Triangles that may be, and measuring the Bases and Perpendiculars by the same Scale that the Plott was laid down by.

But in order to cast up the small irregular Pieces comprehended between the Station-Lines and Bounder; if you reduce them into Triangles, &c.

Especially as they will be a great many in Number, so you will very much err in laying of them down first, and taking them off afterwards, especially if the Scale you protract by, be very small, where 10 or 12 Links of a Chain is hardly to be estimated though the Scale be well divided, and the Points of the Compasses very fine: For the removal of this Inconvenience, I shall here shew a way whereby you may cast up these small Quantities, let the Scale be never so small, as exactly as any of the greater parts of the Field.

Suppose the small irregular Pieces between the Station-Lines and Bounders, *Fig. 14*, were to be cast up.

First lay the Field-Book before you, where you will find the Length of the first Offset (as measured in the Field with your Offset Staff) from $\odot 1$ at *a*, to be 56 Links, and the second at 540, in the Chain-Line 140, forming the small Trapezia, *a*, *Vide Fig. 16*.

Now if you add the Offset 56 to the next 140, the Sum is 196, the half of which is 98, the equated Breadth; multiply the Length 540 by 98, the Product is 52920, the content of the Trapezia, *a*, in square Links.

Add 140 to 36, the Sum is 176, the half Sum 88, subtract 540 from 826, the Remainder is 286, the Length of the Trapezia, *b*; therefore multiply 286 by 88, the Product is 25168, the Content of the small Trapezia, *b*.

Subtract 826 from 1120, the Remainder is 294, the Length of *c*; and because both the Offsets are alike, multiply 294 by 36, the Length of the perpendicular Offset, the Product is 10584, the Content of the small Piece, *c*.

In the same manner deal with the rest of these small Pieces round the Field, and set down the

the Product of each in an orderly manner one under another; so shall the Sum give the exact Content of these small Pieces, which added to that within the Station Lines, gives the true Content of the Field in square Links, which reduce into Acres, &c. as before directed.

Note, The Performance of this being tedious, I shall in the next Chapter lay down a more Practical Method for casting up the Content of any Piece of Land.

S E C T. I



F R A C T I O N . I I I .



C H A P. III.

*Shewing the Use of the Theodolite
in Surveying Land by the help of
the Needle and Limb together.*

S E C T. I.



IN this Method of Surveying Land, the Angle which every Line makes with the Meridian is measured by the Limb of the Theodolite, and therefore much preferable to that before mentioned in the foregoing Chapter by the Needle only, because the Degrees and Minutes are better estimated on the Limb of the Instrument than 'tis possible they should be in the Box of the Circumferentor; and this gives the Theodolite the preference to any other Instrument, because we can work by the Limb only, without regarding the Needle at all; but if it be more convenient to make use of the Needle, we may do it in the following manner, being the most exact and absolute Method yet known for Surveying large and spacious Tracts of Land.

For the Needle being observed to play well, when it hath settled in the direction of the Meridian and is at rest, the Box may be moved round the fixed Center by turning the Index on the Limb and the Point mark'd with 360 in the Box, brought directly against the north End of the Needle

Needle, with greater Exactness than a Degree, and its Parts can be estimated in any other Part of the Box; besides we have this Advantage which is very considerable, that we can make use of a short light Needle whose friction being less, plays better than a longer and heavier.

Let the Lines $o a$, $b c$, $d e$, f , in Fig. 17. represent the Station Lines near the Bounders of a Field; then the Angle which each makes with the Meridian may be observed in the following manner.

First, having set up a Mark at o , Measure forwards with the Chain on the Line $o a$ to a 600 Links.

Plant the Instrument at a , and bring the Index to 360 on the Limb, and turn the whole Instrument about (whilst the Needle hangs in the direction of the Meridian) till 360 in the Box is brought directly against the north End of the Needle, and there fix the Instrument, then is the Telescope set in the direction of the Meridian also; and in this Position is the Instrument to be planted at every Station.

Now turn about the Index till the Hair in the Telescope cuts the Mark left at o , and note in the Field Book the Degrees and Minutes which the Index cuts on the Limb, viz. 207 Degrees 20 Minutes, being the Quantity of the Angle which the Line $a o$ makes with the Meridian.

Remove the Instrument from a , leaving a Mark at that Station and proceed with the Chain to b , and there plant the Instrument, then bring the Index to 360 on the Limb, and 360 in the Box exactly to the north End of the Needle as aforesaid, and direct the Telescope to the Mark left at a , and note the Degrees and Minutes cut on the Limb by the Index, viz. 285 Degrees 10 Minutes, which is the bearing of $b a$ or Quantity

tity of the Angle which that Line makes with the Meridian.

It would be Tautology to repeat the manner of measuring the other Lines and Angles in this Figure, but observe that when the Instrument is fixed in the direction of the Meridian, we frequently observe the Needle by moving it from the Point at 360 with a Knife, &c. then if it swings backward and forward freely without jogging or stopping, and settles again to 360 exactly; we may conclude the Instrument is right in the direction of the Meridian to make an Observation.

If you suspect the Needle to be acted upon by some hidden magnetick Power, as when you are Surveying in mountainous Lands, where there may possibly be Iron Mines in the Earth, which will attract the Needle, you may observe whether or no it be drawn aside in the following Manner.

As when the Instrument was planted at e , the North End of the Needle pointing to 360 in the Box; after the bearing of $e d$ was noted, direct the Telescope forwards to f , and note the Angle which the Index cuts on the Limb; viz. $200^{\circ} 5' 0$, then the Instrument being planted at f , because the bearing of $e f$, observed at e , is more than 180° ; subtract 180 there-from and to the Remainder $2^{\circ} 0' 5' 0$ on the Limb, set the Index exactly; but if the bearing of $e f$ had been less than 180 , add 180 thereto, and to that Number, being the Index on the Limb, now turn about the whole Instrument till the Hair cuts the Staff left at e , and then, if the North End of the Needle points to 360 , as at the last Station, the Bearing of that Line is truly observed.

For

For the magnetick Power that attracts the Needle, being supposed at a great Distance, the Direction on such a Piece of Land as is commonly surveyed by the Theodolite, will be the same: But if the attractive Power be near the Instrument, the Needle will incline thereto.

Now follows the manner of protracting these Observations,

<i>Lines</i>	<i>Links</i>		<i>Sta.</i>	<i>Deg.</i>	<i>Min.</i>
<i>a, o,</i>	600	—	<i>a,</i>	207	20
<i>b, a,</i>	500	—	<i>b,</i>	285	10
<i>c, b,</i>	1000	—	<i>c,</i>	190	00
<i>d, c,</i>	500	—	<i>d,</i>	91	55
<i>e, d,</i>	500	—	<i>e,</i>	125	20
<i>f, e,</i>	1600	—	<i>f,</i>	20	50
<i>o, f,</i>	500	—	<i>o,</i>	289	15

S E C T. II.

A new Method of protracting any Observations made in the Field by the Needle.

BY which a Plan may be drawn on the Paper from one Meridian only, and all the Angles therein laid down by once applying the Protractor to that Meridian by the help of a parallel Ruler, being very exact and expeditious.

Provide a circular Protractor, whose Numbers encrease the same way as on the Limb of the Theodolite, and a parallel Ruler of a convenient Length, then draw a Right-line *N S*, *Fig. 17.* (with a black lead Pencil) for a Meridian, and assign a Point therein, as at *o*, to which Point apply the Center of the Protractor, and turn it about till the Diameter lyes on the Line *N S*; with 180 towards *N*, (that part of the Limb of

of the Theodolite being always kept Northward of the Field.)

The Protractor held in this Position, lay the Field Book before you, and against 107 Degrees 20 Minutes, the bearing of the First Line *a o* close to the Limb of the Protractor, make a Mark with the protracting Pin or Needle, and close to that Mark write *a* with a black lead Pencil.

Hold the Protractor in the same Position, and against 285 Degrees 10 Minutes, the bearing of the next Line *b a*, make a Mark with the protracting Pin, and close to that Mark set *b*.

In the same manner keeping the Diameter of the Protractor close to the Meridian as it was at first laid; make a Prick with the protracting Pin, close to the Limb of the Protractor, against the bearing of each respective Line as noted in the Field Book, and close to each Prick set the Letter or Number of that Line; so against 190 Degrees the bearing at *c*, make a Prick and write *c*, against 91 Degrees 55 Minutes write *d*, against 125 Degrees 20 Minutes write *e*, &c. *Vide Fig. 17.*

Having mark'd the bearing of each Line round the Protractor, lay it aside, and apply the edge of your plotting Scale to *o* at the Center, and *a* mark'd by the Limb of the Protractor; the beginning of the Numbers coinciding with *o*, and encreasing towards *a*, and prick off 6 Chains the Length of the Line *o a*, and with Ink draw the Line *o a a*.

Lay the parallel Ruler to the prick'd Line *p o b r*, so that the edge cuts the central Point at *o*, and the Point at *b*, as mark'd by the Limb of the Protractor; and move it parallel till the Edge cuts the Point at *a* in the Line *p a b r*, and with the Point of your Compasses draw the occult Line *p a b r* by the Edge of the parallel Ruler; then because the Length of the Line

a b

$a b$ is 5 Chains, lay the plotting Scale to g and Prick off 5 Chains, and draw the Line $a b$.

When you had drawn the occult Line $p a b r$, through the Point a , you might set $a b$ thereon towards p as well as towards r ; but if you observe in what Direction the Letter b , as mark'd by the Limb of the Protractor, stands from the central Point o , in the same direction must the Line $a b$ be set from the Station Point a ; also when the Ruler is laid to the Station b , you cannot be at a loss whether you should draw the Line $b c$ upwards or downwards, if you observe in what direction the Letter c stands from the central Point o ; therefore in the same Direction draw $b c$ from b , or the Angles mark'd external in the Field Book will be a sufficient Direction.

Lay the parallel Ruler to the central Point o , and the Mark at c , and move it parallel in that Direction, till the Edge cuts the Point b at the end of the Line $a b$, and by the Edge of the parallel Ruler, draw an occult Line, setting thereon from b 10 Chains, and draw the Line $b c$.

Again lay the Edge of the parallel Ruler to the Point at the Center o , and to the Mark at d , and move it up to c , and draw $c d$.

In the same manner deal with the other Lines and Angles, so shall the last Line $f o$ cut through the Point o , and its Length be 5 Chains, as noted in the Field Book, which proves the Plott to be truly laid down.

In these Observations the Station Lines only are inserted, the Offsets from thence to the Bounders are omitted, the manner of plotting them being already laid down before.

When the Bounders of the Field are drawn, and the Name thereof entred in the middle of the Plott, you may with a piece of Bread rub

off the Marks that were made with the Pencil round the Edge of the Protractor and meridian Line, so will the Plott be ready for casting up.

But if several Fields are to be plotted together, you must draw a Line through the first Station Point in each, parallel to the Meridian in the first Plott, from which the Plott of each Field may be laid down in the same manner as *Fig. 17.*

Observe, neither the Circle nor Figures, expressing the Angle which each Line makes with the Meridian, are used in Practice, though inserted in the Scheme to demonstrate the Nature of the Work; also if you lay the Edge of the thin plotting Scale close to the Edge of the parallel Ruler, and move it forwards on the Paper with the parallel Ruler, till the Edge of the Scale cuts the Point at *a*, and bring the beginning of the Numbers on the Scale to the Point *a*, you may draw the Line *ab* by the Edge of the Scale held in that Position to 500, the Length of the Line without drawing any other but the Station Line it self.

S E C T. III.

A New Method of calculating or casting up the Area of a Plott of Land in Acres, &c.

ACcording to the Rules before mentioned in Chap. 1. the whole Plott must be reduced into Trapezias and Triangles, and the Length of each Base and Perpendicular measured by the Scale; but since it is often necessary to lay down the Plott by a small one, as $\frac{1}{4}$ of an Inch or less; if you err 8 or 10 Links in taking off the Length of the Bases and Perpendiculars (which may easily happen if the Lines be not drawn very

very neat and small) and there being several such Bases and Perpendiculars, the Error may be considerable in the whole Plott, and then also the Base and Perpendicular of each of these Triangles must be multiplied together severally, and their Products added together for the whole Content.

Whereas by this Method the whole Plott, (let it consist of many Sides or few) is cast up by applying the Scale but to one Base and one Perpendicular, and consequently by one Multiplication, and the Truth of the Work is demonstrated by the first Theorem in Chap. 1. viz. That Parallelograms (and consequently Triangles) constituted upon the same Base, and between the same Parallels are equal.

Let the four-sided Figure $abcd$, Fig. 18. be reduced to a Triangle, whose Area shall be equal to that of the four-sided Figure.

First extend one of the Sides as cd , then lay the parallel Ruler to the Points a and d , and move it parallel till the Edge cuts the Point b , then by the same Edge make a Mark in the extended Line cd at e : Lastly lay a strait Ruler to the Points e and a , and draw the Line ea , so shall the Area of the Triangle ace , be equal to the Area of the four-sided Figure $abcd$.

For the Triangles doe , and boa , having Bases of the same Length, and lying between the same Parallels are evidently equal; then if the Triangle boa is left out of the four-sided Figure $abcd$, and the Triangle doe , taken in, and the Areas of these two Triangles being equal; it follows, that such an equal Quantity of Space is left out in one part of the Figure as is taken in on the other, and the Area must still be the same.

Again

Again, let *Fig. 19.* be reduced into a Triangle.

First extend the Line *fa*, and apply the parallel Ruler to the Points *a* and *b*, and move it up parallel to the Point *a*, and where the Edge cuts the extended Line *fo*, make a Mark at *g*, then lay the Ruler to the Point *g* and *c*, and move it up to *b*, and make a Mark in the extended Line or Base at *h*.

Lay the Ruler to the Points *b* and *d*, and move it to *c*, then make a Prick in the Base at *i*.

Lay the Ruler to the Points *i* and *e*, and move it to *d*, and make a Mark in the Base at *k*.

Lastly draw the Line *ke*, so shall this seven-sided Figure be reduced to a three-sided one whose Areas are equal, so may the Triangle *fek* be cast up by one Multiplication only.

But Note, instead of laying the Ruler to the Points *i* and *e*, if you had laid it to *df*, and moved it up to *e*, and drawn the Line *zd*, the Triangle *zdi*, would have contained the same Area as *fek*, and this often is necessary to prevent the Sides of the reduced Triangle being extended too long, and making the Angles thereof too acute.

Apply the same Scale by which the Plott was laid down to the Base, and measure its Length, also measure the Length of the Perpendicular; multiply these two Sums together; the half of their Product is the Content of the Plott in square Links, which reduce into Acres, &c. as before directed.

Also observe that we commonly chuse to extend one of the shortest Sides of the Plott to be the Base of the Triangle, as the Side *fo* which we draw with a black lead Pencil as *ok*, as well as *ke*, *id*, or *zd*, and rub em off again with a Piece of Bread, as soon as the Content of the Field

Field is entred with its Name in the middle thereof.

If in using the parallel Ruler at the first Tryals you find it apt to slip on the Paper, which you may do if you be not very careful to hold it close down thereto, that Inconvenience may be prevented, if you make use of three small Pins or Needles, thus: Stick the three Pins in the three First Angles, as at o , a , and b , then apply one of the inner Edges of the parallel Ruler, to the first and third o and b , and move the other inner Edge to the Second at a , take out the Pin at the Second, and put it in the Base or Line extended where the Ruler cuts it as at g ; again lay the Ruler to this Pin at g , and to another at the Fourth Angle at c , and move the Ruler to the Fifth Angle at d , take out the Pin at d , and stick it in the Base at h , and proceed in this manner with the rest till the Plott is reduced.

S E C T. IV.

Shewing how to reduce the irregular Bounders of a Field to strait Lines, in order to find the Area thereof.

L E T $abcdefghik$, Fig. 20. represent the Bounders of a Field, whose Content is desired.

First, produce some one of the longest Sides as ik , then lay the parallel Ruler from the Angle i to g , the next but one, and move it up to the Point b , and where it cuts the Line produced, make a Mark at r , and draw the strait Line rg , and it will reduce that Side of the Figure bounded by the two Lines ib , and bg , to another bounded by rg one Line only.

In

In like manner rg being produced, and the parallel Ruler laid from g to e , and moved up to the Angle f , the Edge cuts the extended Line rg , at y ; Secondly, lay the Ruler from y to d , and move it up to e , it cuts the extended Line eg at z ; Thirdly, lay the Ruler from z to c , and move it up to d , and where it cuts the extended Line rg , make a Mark at x ; Lastly, draw the straight Line yc , so shall the Side gc which consisted of the four Lines gf , fe , ed , and dc , be reduced to the Side yc consisting of one Line only, and in like manner might we proceed, if the Lines were never so many; so may the ten-sided Figure be reduced to a four-sided one, and then to a Triangle which may be cast up by one Multiplication only.

This is the same Method before laid down for reducing a many sided Figure to a Triangle, but if you have not a parallel Rule, do thus:

Having produc'd the Side ki , lay the Edge of a straight Ruler from i to g , then take with a pair of Compasses the Distance from b to the Edge of the Ruler, and with this Distance let one Point of the Compasses move gently close to the Ruler, while the other traces out a Line parallel to it, and crosses ki at r , and draw rg as before.

In the same manner deal with the other Sides, using the Compasses in this manner instead of a parallel Ruler.

Provide a plate of thin Brass in form of an Arch of a Circle, near whose ends let there be drill'd small Holes, through which string it with a very fine Hair; and then an Hedge as gc , Fig. 20. bends in and out in several Places, and those Bends contain very small Spaces; lay the Hair over it length-ways, so that the Quantities cut off from the Figure thereby, may be equal
to

to those added to it; and with a protracting Pin near the ends of the Hair, make two Marks, through which, draw a strait Line, and so will this irregular Side be reduced to a regular one; and here it may be observ'd that in very small Bends by the Eye, you may judge better than by the Compasses.

But if Hedges consist of large Curvatures, chuse out such Points, and so many of them that Right-lines drawn from Point to Point may vary the Quantity by such Quantities only as may be rejected, and herein the Hair will be a Ready Assistance

S E C T. V.

The manner of reducing hypotenusal to horizontal Lines.

WHEN we meet with an Hill in Surveying a Piece of Land; we can only measure the hypotenusal or slope Lines thereof, on the Superficies of the Hill, which being considerably longer then the Base or level Lines on which the Hill is situated, as the Lines ab , bc , Fig. 21. are longer than ao , oc , therefore when we plott this Hill (because we cannot make a convex Superficies upon a piece of plain Paper) we must reduce the hypotenusal to horizontal, Lines that all the Lines in the Plott may be laid down alike in *Plano*.

For the Lines of level only must be express'd in a Plott; that every Field therein may lye in its true Situation; for if ab , and bc , were laid down on Paper as measured in the Field, they would reach to d , and not only thrust the next Hedge out of its true Position, but also take up
a great

a great Space in the next Field, making that too little.

Let *Fig. 21.* represent an Hill; at the foot of which the Theodolite is planted, which being set level in order to measure the Angle at *a*, the Telescope when directed towards *b*, at the top of the Hill, cuts the Ground; therefore take the Pin out of the Quadrant, and elevate the Telescope to the Mark at *b*, (which must be set the same Distance from the Ground as the Telescope is) and when the Hair cuts the Mark at *b*, the Index shews the horizontal Angle on the Limb, and the Quadrant the Angle of Elevation *ba* *o*, 25 Degrees 50 Minutes both at the same time, which note in the Field Book one over against the other.

The Instrument removed from *a*, and planted level on the top of the Hill at *b*, the Telescope when directed towards *c*, cuts the Element, therefore take out the Pin from the Quadrant, and depress the Telescope to the Mark at *c*, and then the Quadrant will cut 21 Degrees 34 Minutes, and the Length of *a b*, as measured up the Hill, by the Chain is 1200 Links, and *bc* 1416.

In order therefore to plott these Observations, first, draw the Right-line *ad*, but do not set the Length 1200 Links thereon, because the Angle of Elevation is noted in the Field Book against the horizontal Angle, which shews that this Line is to be reduced to a Level; therefore lay the Center of the Protractor to *a*, the Diameter coincident with *ad*, and against 25 Degrees 50 Minutes, the Angle of Elevation, make a Mark, and through it draw the obscure Line *ab*, setting thereon 1200 Links the Length of the Hypothenuse, at the End of which make a Mark at *b*.

Having drawn the Angle of Elevation *ba* *o*,
take

take a Square Protractor or any other Square that hath one Right Angle, and two strait Edges and apply one Edge thereof to the Right Line ad , whilst the other Edge cuts the Point b in the obscure Line ab , and thereby let fall a Perpendicular from the Point b , which falls on the Line ad at o , so shall the Line ao , be the true horizontal Line which must be laid down in the Plott.

In the same Manner reduce the Hypothenuse boc , by first drawing the Angle of Depression doe , $21^{\circ} 3' 4''$ setting the Length of the Hypothenuse bc 14, chain 16 Links on the obscure Line oe , and where that Length 1416 Links reaches from o , make a Mark at e . Lastly, from e let fall a Perpendicular on the Line od , which falls at c , so shall the Line oc , be the true Horizontal Line.

Or else having noted the Quantity of the Angle of Elevation, and Length of the Hypothenuse in the Field Book, you may find the horizontal Line by the help of the following Table.

A Table shewing how many Links to deduct out of every Chain's Length in the Hypothenusal-Line.

Deg.	Min.	Lin.	Deg.	Min.	Lin.	Deg.	Min.	Lin.
4	3	$\frac{1}{2}$	19	57	6	29	32	13
5	44	$\frac{1}{2}$	21	34	7	30	41	14
7	1	$2\frac{1}{2}$	23	4	8	31	47	15
8	6	1	24	30	9	32	52	16
11	29	2	25	50	10	33	54	17
14	4	3	27	8	11	34	55	18
16	16	4	28	21	12	35	54	19
18	12	5				36	52	20

Having

Having the Angle of Elevation 25 Degrees 50 Minutes, and the Length of the Hypothenuſe ab , 12 Chains given thence to find the Length of the horizontal Line.

Look in the Table for 25 Degrees 50 Minutes, and againſt it you will find 10 Links, and ſo many muſt be deducted out of every Chain in the Length of the Hypothenuſe, then if 1 Chain or 100 Links requires 10 Links to be deducted from thence, 12 Chains or 1200 Links, requires 120 Links to be deducted; therefore ſubtract 120 Links from 1200, the Remainder is 1080, the Length of the horizontal Line ao .

Again, the Angle of Depreſſion at b , is 21 Degrees 34 Minutes, and the Length of the Hypothenuſe or ſlope Line bc 1416 Links, you will find in the Table againſt 21 Degrees 34 Minutes 7 Links, then if $100:7:1416:99$, therefore ſubtract 99 Links out of 1416 the Length of the ſlope Line, the Remainder is 1317 Links, the Length of the level Line oc ; But if you cannot find the given Angle of Elevation in the Table, make uſe of that which approaches neareſt thereto; and *Note*, Surveyors in Practice ſeldom take notice of a gradual Aſcent, if it does not make an Angle of above 5 or 6 Degrees or thereabouts, the difference between the ſlope and level Line, being then inconfiderable, except in ſome extraordinary Caſe, and then 'tis ſafeſt to make uſe of the firſt Method here laid down, becauſe the Table is too ſhort, but if you have a correct Table of Sines and Logarithms, you may make uſe thereof.

If you are working with the Chain, and would find the horizontal Line of an Hill, you may

may carry a small Quadrant in your Pocket, with which measure the Angle of Altitude, and note it in the Field-Book against the Chord or Sextant of the horizontal Angle observed at that Station, (but let the Mark be set the same Distance from the Ground with your Eye when you observe the Angle of Altitude) and proceed to reduce the Line as aforesaid.

Also you may observe an Angle of Altitude if you have only the plain Table in the Field, by turning it down into the notch of the Ball and Socket, making it stand Perpendicular by applying the String and Plummet thereto, and then the Index and Sights screwed to the Center of the Table may indifferently serve the turn, but a Quadrant is better.

You must shade over that part of your Plott where the Lines are thus reduced with the Representation of Hills, lest another Person should measure them by the same Scale with the other Lines, and find them to differ.

If a Field have the bottom and top Lines level, and both Sides rising alike, it is to be accounted but as a declining level, and to be measured as a Level Ground in regard of the Quantity of Superficies, though the side Lines must be reduced to make a regular Plott in respect of the adjacent Fields that are level; but if a Ground be level at one End and both Sides, and an Hill rising up along the Middle, or if there be several Hills in the Middle, thereof the Superficies will be more than in a Plain bounded by the same Limits.

Now Surveyors differ in their Opinion, in respect of casting up the Content of such a Field; some argue on the Tenant's Behalf, that since all Vegetables stand in a Perpendicular on the Earth; (that is, grow strait upwards) as much will

G

grow

grow on the horizontal Line as on the Hypothenuse, and therefore the Lines ought to be all reduced to a level, and the Content to be deduced from the Plott so laid down.

Others say that there ought to be marks placed on the top of the most remarkable Hills, and the Chain drawn over Hill and Dale, and the slope Lines laid on the Paper of the same Length as measured in the Field, and the true Content in Acres, &c. deduced from thence although the Slopes be reduced afterwards, that the Field may be laid in its true Situation in respect of others adjacent in the fair Plott.

'Tis hard to determine which way is to be practised in all Cases; for though by the last Method you will have the true Quantity of Superficies more nearly given, yet the allowance in the first is often but reasonable, if the Soil of the Hills is not so profitable as if the whole Field was situated on a Plain, but the Reader may use which he shall think most proper.



C H A P. IV.

Shewing how to Survey and make a perfect Draught of several pieces of Land lying together as a Manor, &c. Also how to compare the Bearing and Angles one with another, at each Station, as observ'd by the Theodolite, in order to correct any Error that may arise in measuring the Angles in the Field as well as protracting them on Paper.

S E C T. I.



HAVING in the former Chapters laid down the best and most practical Methods for measuring any Piece of Land by the most proper Instruments, I here subjoin the manner of Surveying several Parcels lying together; an Example of which may be taken from the small Tenement or Farm, *Fig. 22.*

First I take a View of the Land, considering at which Part thereof it will be most convenient to begin, and proceed with the Work; and because 'tis best working in a Lane as often as an Opportunity presents; therefore I set up the Theodolite at $\odot 1$ in *Charlton Field*.

Then I enter in the Field-Book the Title of the Survey, and in the middle Column $\odot 1$, and then send a Station Staff forwards in the Lane, as far as I can see distinctly, (the farther the better) as to $\odot 2$, (and when the Station Lines are within the Fields, I send the Staff to the next eminent Bend in the Hedge, or even to the farther end thereof, if the Line from the Instrument to the Staff be not at too great a Distance from the Hedge, so as to cause Offsets greater than a Chain or a Chain and half, or thereabouts, for Offsets taken too long are not so easily laid off at right Angles from the Station Line) and to that Staff at $\odot 2$, I direct the Telescope, and note the Degrees in the Box cut by the north End of the Needle, *viz.* 356 Degrees 10 Minutes, which I enter in the Field-Book for the Bearing of this first Station Line.

Then I set up a Staff in the Hole over which the Center of the Instrument was plac'd, to which Staff I direct one of my Assistants to apply the Ring at one End of the Chain, whilst the other Assistant stretches it out in a right Line towards $\odot 2$, letting it lye on the Ground in that Direction; till the Occurrences in this Chain's Length are entred in the Field-Book, *viz.* I measure the Distances of the Chain from the Bounders of each Field, which I enter in the Columns of Offsets, that on the right Hand of the Chain in the right Hand Column, and that on the left in the left Hand Column; and if the Land is Part of that which I am about to survey, I write in one
of

of the outside Columns by what Name it is call'd, but if it belongs to a Stranger, I write the name of the Owner thereof, and in all Cases express to which Land the Hedge belongs.

So at the Length of 20 Links from $\odot 1$, I lay the Offset Staff at right Angles with the Chain, and measure the Distance from thence to the corner of Turfy Leas, which I find to be 15 Links; therefore in the middle Column representing the Station Line I write 20, and against it in the right Hand Column of Offsets I enter 15; likewise when I come to 40 Links in the Chain-Line I am against the Corner of Cow-pasture; therefore, I lay the Offset Staff to the Chain, and measure the Distance from thence to the Corner of Cow-pasture 80 Links, which I enter in the left Hand Column of Offsets against 40 in the middle Column, denoting that at the Length of 40 Links from $\odot 1$ the Offset, 80 Links reached the Corner of Cow-pasture on the left Side of the Station-Line.

The Hedges on each side the Lane, running on very nearly strait from these Corners, I take no more Offsets in this first Chain's Length nor at the second; but when I have laid the Chain a third time, and come against 80 Links, I there take an Offset on the left Hand of the Chain Line, because the Hedge varies its Direction, making a considerable Bend; for though the Distance from the Chain to the Hedge continually varies from the Corner to this Place; yet I only take Offsets at each End, omitting the intermediate Parts; since when the extreams of a right Line are given, that right Line is also given, but when the Hedge runs on with a continued but irregular Curvature, then I take Offsets at every Chain or half Chain's Length, or oftner as the Thing requires.

First I take a View of the Land, considering at which Part thereof it will be most convenient to begin, and proceed with the Work; and because 'tis best working in a Lane as often as an Opportunity presents; therefore I set up the Theodolite at $\odot 1$ in *Charlton Field*.

Then I enter in the Field-Book the Title of the Survey, and in the middle Column $\odot 1$, and then send a Station Staff forwards in the Lane, as far as I can see distinctly, (the farther the better) as to $\odot 2$, (and when the Station Lines are within the Fields, I send the Staff to the next eminent Bend in the Hedge, or even to the farther end thereof, if the Line from the Instrument to the Staff be not at too great a Distance from the Hedge, so as to cause Offsets greater than a Chain or a Chain and half, or thereabouts, for Offsets taken too long are not so easily laid off at right Angles from the Station Line) and to that Staff at $\odot 2$, I direct the Telescope, and note the Degrees in the Box cut by the north End of the Needle, viz. 356 Degrees 10 Minutes, which I enter in the Field-Book for the Bearing of this first Station Line.

Then I set up a Staff in the Hole over which the Center of the Instrument was plac'd, to which Staff I direct one of my Assistants to apply the Ring at one End of the Chain, whilst the other Assistant stretches it out in a right Line towards $\odot 2$, letting it lye on the Ground in that Direction; till the Occurrences in this Chain's Length are entred in the Field-Book, viz. I measure the Distances of the Chain from the Bounders of each Field, which I enter in the Columns of Offsets, that on the right Hand of the Chain in the right Hand Column, and that on the left in the left Hand Column; and if the Land is Part of that which I am about to survey, I write in one
of

of the outside Columns by what Name it is call'd, but if it belongs to a Stranger, I write the name of the Owner thereof, and in all Cases express to which Land the Hedge belongs.

So at the Length of 20 Links from $\odot 1$, I lay the Offset Staff at right Angles with the Chain, and measure the Distance from thence to the corner of Turfy Leas, which I find to be 15 Links; therefore in the middle Column representing the Station Line I write 20, and against it in the right Hand Column of Offsets I enter 15; likewise when I come to 40 Links in the Chain-Line I am against the Corner of Cow-pasture; therefore, I lay the Offset Staff to the Chain, and measure the Distance from thence to the Corner of Cow-pasture 80 Links, which I enter in the left Hand Column of Offsets against 40 in the middle Column, denoting that at the Length of 40 Links from $\odot 1$ the Offset, 80 Links reached the Corner of Cow-pasture on the left Side of the Station-Line.

The Hedges on each side the Lane, running on very nearly strait from these Corners, I take no more Offsets in this first Chain's Length nor at the second; but when I have laid the Chain a third time, and come against 80 Links, I there take an Offset on the left Hand of the Chain Line, because the Hedge varies its Direction, making a considerable Bend; for though the Distance from the Chain to the Hedge continually varies from the Corner to this Place; yet I only take Offsets at each End, omitting the intermediate Parts; since when the extreams of a right Line are given, that right Line is also given, but when the Hedge runs on with a continued but irregular Curvature, then I take Offsets at every Chain or half Chain's Length, or oftner as the Thing requires.

In this manner I proceed with the Chain till I come to the Staff at $\odot_2$, observing as I go along the Bends in the Fences on each side of the Lane, to every one of which I take an Offset, writing the Length of each on the right or left side of the middle Column in the Field-Book representing the Station Line, according as they were laid off in the Field.

Note, the Mark $\odot$ in the Field-Book denotes a Station; *B* a Bearing, $<$ an Angle, *cu.* the cutting of an Hedge by the Chain, *a g.* some remarkable Object on the farther side of the Hedge, as another Fence shooting up thereto; *ret.* return to a former Station, &c.

Being come to $\odot_2$, I there plant the Instrument, and send the Station Staff forwards in the Lane as far as I can see it, as to $\odot_3$, and then bring the Index to 360 on the Limb, and turning the whole Instrument about I direct the Telescope to the Staff left at $\odot_1$, and there fix the Instrument; and then turn about the Index on the Limb, till through the Telescope I see the Staff at $\odot_3$, and then find that the north End of the Needle points at 338 Degrees, and the Index cuts on the Limb 161 Degrees 50 Minutes; therefore under $\odot_2$, in the middle Column of the Field-Book, I enter 338 Degrees, and under that 161 Degrees 50 Minutes, denoting that at the second Station the Bearing of the second Length is 338 Degrees, and the Angle which the Index cuts on the Limb is 161 Degrees 50 Minutes.

The Rule I observe in measuring each Angle is this; first I bring the Index to 360, and with that part of the Limb towards me, I direct the Telescope to a Mark at the last Station, and there fix the Instrument; then I turn about the
Index

Index on the Limb, till I see the Hair in the Telescope cut a Mark at the next Station before me, so shall the Needle shew the Bearing of the next Line, and the Index on the Limb shews the Quantity of the Angle at the present Station.

The Angles and Bearings of the Lines are taken at once setting the Index, as easily and expeditiously as the Angle it self only; therefore insert the Bearing of each Line in the Field-Book, as you see in the Form thereof; for then you may prove the Truth of your Work in the Field at each Station, before you leave it, by one of the following Rules.

If to the present Bearing, be added 180 Degrees, and from the Sum you subtract the last Bearing, then the Remainder will be the present Angle.

Or if to the present Angle, you add the last Bearing, and from the Sum subtract 180 , then will the Remainder be the present Bearing.

But if the Degrees to be subtracted are more than those from which they are to be subtracted, the latter must be increased by 360 , and then subtract. And if the Remainder be more than 360 , then abate 360 , and the Result gives the Degrees required.

So at $\odot 2$, if to the present Bearing $338^{\circ} 00'$, you add 180° , the Sum is $518^{\circ} 00'$ from which Sum, if you subtract the last Bearing at $\odot 1$, $356^{\circ} 10'$, the Remainder is $161^{\circ} 50'$ equal to the present Angle.

Likewise, if to the Bearing at $\odot 3$ $1^{\circ} 30'$, you add 180 Degrees, the Sum is $181^{\circ} 30'$, which is less than $33800'$, the Bearing of the last Station, therefore $181^{\circ} 30'$ must be increased by 360 , and then the Sum is $541^{\circ} 30'$, from which if you subtract 338 , the Bearing of the last Station, the Remainder will be $203^{\circ} 30'$, equal to the present Angle.

In like Manner may any other Angles be examined, and if found erroneous, the Error may

be corrected, before 'tis communicated to the following Part of the Work.

Therefore when you have noted the Bearing of the present Station, write it in one of the outside Columns of the Field-Book, and adding 180 thereto, subtract the Bearing at the last Station there-from; and then, if the Angle thus calculated from the Bearings, doth agree with that which the Index cuts on the Limb, you may conclude the Angle is rightly observed, and therefore may be entred in the Field-Book.

. But observe, tho' the Numbers thus compared will be very nearly alike, yet sometimes they may differ some few Minutes, because the Divisions in the Box being so much smaller than those on the Limb, the Degrees and Minutes can't be estimated alike in both; but yet you will be sure always to correct and avoid any gross Error before you proceed with the following Work; and to this End the before-mentioned Rules are of excellent Use.

These Directions I shall not repeat, tho' I make Use of them throughout the whole Work, unless any thing new occurs in measuring of the other Lines and Angles, referring the Reader rather to the Field-Book and Plan of the Work, than tiring him with Repetitions.

From $\odot 2$; I proceed with the Chain towards $\odot 3$: but at twenty Links in the first Length from $\odot 2$, I am against the Hedge that parts Home-close from Turfy-Leas; therefore I take an Offset thereto perpendicular from the Chain Line, and enter in the Field-Book *a g* 17 Links, and this will hereafter be of Use in closing the Plott.

Being come to $\odot 3$, I there observe and prove the bearing and Angle at that Station, and then proceed with the Chain towards $\odot 4$; but first at

$\odot$ or

⑥ or the present Station, I measure an Offset to the right 10 Links, and to the left 20 Links; at 41 in the Chain Line; I am against the Orchard Hedge at 204, the Orchard Pales at 161, I am against the Gate that leads into the Yard, and also against another that goes into Cow-Pasture; therefore to each of these Remarks I measure an Offset from the Chain Line, and enter them in the Field-Book.

In going from ④ 4 to ⑤ 5, the Chain touches the Brow of the Ditch at 2 Chain 20 Links from the last Station; therefore against 220 in the Field-Book I write 0, denoting that there was 0 or no Distance from the Chain to the Ditch, and by the Brow of the Ditch is meant the determined Distance of 5 Links from the Stem of the Hedge.

Being come to ⑥ 6, I send a Staff to the farther Side of the Field called the Stockin, and if I cannot see the Mark through the Hedge, I cause the Bows to be removed or held back till I can plainly see the Mark, and if that can't be done I make my Station a little on this Side, or else beyond such a thick Place till I can plainly see the Mark, and draw the Chain through the Hedge in a strait Line, and where it cuts the Hedge I write *cut*, as here it does at 10 Links; but if the Fence is a Wall I allow for the Thickness thereof, and always measure the nearest Distance between Station and Station that can possibly be.

Being come to ⑨ 9 in the Stockin, I cause a Staff to be set up in the very Corner of the Field next the Lane where the Bounders meet, to which I measure from ⑨ 9; so shall the End of this Line coincide with the Offset which I took to this corner from the Station Line in the Lane, which
will

will be a Proof that the Work is truly laid down when I come to protract it.

If upon a Piece of Paper with the Pen only you make an Eye-Draught of the Lane, and that Field which you have finished, setting your Station Lines with their Numbers, as you made them in the Field, you will plainly see your Work as you go along, and be able to distinguish which Bounders of the present Field are already observed in the Precedent, as well as be directed, with a great deal of Ease, how to proceed with your Work, when you come to protract it.

Having made all the necessary Observations round the *Stockin*, I return to $\odot 9$, and with 360 on the Limb towards me I direct the Telescope to a Mark, at the last Station before I came to this, *viz.* $\odot 8$, and fixing the Instrument there, I next direct the Telescope to $\odot 10$, and note the Angle and Bearing at that Station; then I lay the Chain through the Hedge from $\odot 9$ towards $\odot 10$, and take an Offset to the Fence where each Partition Line joins it on the other Side, by the Help of which, together with the other Offsets on the further Side in the Lane, most of the inward Fences of the Orchard, Garden &c. may be drawn.

From $\odot 10$ I cannot see into the very Corner next the Lane, therefore I take an Offset thereto 20 Links from the Station Line, and so are the out Lines of the Garden, Yard, &c. finished.

Then I return to $\odot 8$ in the *Stockin*, and here it may be observed, that when I design to return to any Station, before I leave it I cut up a Turf with a little Paddle, which I fix in one End of the Offset-Staff, or make some such Remark that I may be sure readily to find the Place in which the Station Staff before stood; and in the Field-Book to this Mark $\odot$ I write return; then planting the Instrument at $\odot 8$, I direct the Telescope

scope to the Mark left at $\odot$ 7, and here also I observe as a general Law, to observe the Angle with that Line which was measured immediately before I came to the Station where I took the Angle the first time: So here I observe the Angle made with $\odot$ 7, $\odot$ 8, and not with any other, as $\odot$ 8, $\odot$ 9; therefore according to this constant Law I direct the Telescope back to $\odot$ 7 in the *Stockin*, and fixing the Instrument there, I next direct the Telescope to $\odot$ 11, in *Home-Close*, and Note the Angle, &c. as in the Field-Book.

After I have measured the Angle &c. at $\odot$ 11, and am going forwards towards $\odot$ 12, at 76 Links of the Chain I perceive my self over against the Fence that parts *Out-Wood* from *Crab-tree-Close*, I therefore ask the Follower of the Chain, how many Arrows he hath in his Hand, he answers 4, therefore I enter in the middle Column of the Field-Book 476, and against that on the left I write 61, the Length of the Offset, denoting, that at the Length of 4 Chains 76 links from $\odot$ 11, I laid off an Offset to the left, 61 Links, and proceed to observe and enter in the Field-Book the rest of the Occurrences round *Home-Close*, closing it at the End of the Line from $\odot$ 12 next the Lane.

Then I return to $\odot$ 12, and proceed to $\odot$ 13, closing *Turfey-Leas* at the Corner; to which I took the first Offsett from $\odot$ 1, in *Charlton-Field*.

In the same Manner I proceed round *Crabtree-Close*, entring the several Occurrences as you find them in the Field-Book.

At $\odot$ 17, I cause a Staff to be set up close to the Fence where the Hedges join one another; to which Staff I measure strait from $\odot$ 17, closing *Outwood* at the Extremity of the Station-Line, which coincides with the Offsett laid off from $\odot$ 7, in the *Stockin*.

Having

Having finished all the Fields on this Side the Lane, I return to $\odot 6$, observing this general Rule, never to make a Tour greater than Necessity requires, but always to close each Field as soon as possible : So instead of going up the Lane from $\odot 2$, if I had turned off into *Turfy-Leas*, and closed first *Turfy-Leas*, and then *Crabtree-Close*, &c. the Work had been done as well.

Being at $\odot 6$, I cause a Staff to be set up in a convenient Place, on the farther Side of *Garrot-Field*, as at $\odot 18$, laying the Chain through the Hedge, from $\odot 6$, towards $\odot 18$; and because the Hedge belongs to the next Field, I write Hedge to *Will. Green*, the Owner of the adjacent Land.

After I have observed the Angle at $\odot 18$, I direct the Telescope to a Staff set up by the River Side, and note the Degrees which the Index cuts on the Limb, viz. $131^{\circ} 10'$; and then measure from $\odot 18$, to that Staff, 300 Links, taking Offsets on each Side the Line to the Brink of the River, as you see in the Figure thereof; and this will be found very useful in all Manner of Practice, where the Bounders are very irregular, that as much Work may be performed at once setting down the Instrument as possible.

From $\odot 18$, I proceed with the Chain to $\odot 19$, and from thence I measure along the Hedge-side that reaches from the River to the Lane; and when I come against the Hedge that parts *Magg-meadow* from *Cow-pasture*, I write, a g. 50 Links, being so far distant from the Chain-Line; and because the Hedge from this Place belonged to *Garrott-Field*, I entred it so in the Field-Book, but now it belongs to *Cow-pasture*; therefore I write Hedge to *Cow-pasture*.

Then returning to $\odot 19$, I direct the Telescope first to $\odot 18$, and then to $\odot 20$, and find

① 19 to be in a strait Line with ① 18 and ① 20; therefore I enter in the Field-Book 180, or Station-Line continued, proceeding to observe and enter down the several Occurrences at ① 20, ① 21, and ① 22, round *Magg-meadow*, and then return to ① 21.

From ① 21, I go to ① 23 in *Cow-pasture*, closing it on the Corner, near ① 1 in *Charlton-Field*; and so is the whole finished, as far as relates to the Field-work.

If there be several Pieces of Land belonging to the same Manor, &c. you are now surveying, that lie dispersed in several Furlongs in Common Fields adjacent to the same Manor; you may from one of your Stations on the Outside of the Plot take the Bearings to each Piece, by causing a Mark to be set up thereon, and measuring the Distance from that Station to each Mark: So may each Piece be plotted in its true Form, and laid in the same Situation in the Plot as on the Land it self: And in your Table of References or Terrier, you may insert the Name of the Furlong where each Piece lies, with the Name of other Persons Land that lies round it, as a Direction to the Steward or other Person, to find each Piece.

Obser-

94 *The Practical Surveyor.* Chap. IV.

*Observations and Dimensions of Land lying in the
Parish of W—, in the County of L— Part
of the Estate of ——— 31st of March, 1724.*

Remarks	Offsets	Station Lines	Offsets	Remarks
Θ 1 in Charlton-Field				
Corner of Cow Pasture, Hedge to Pasture.	B	356°. 10'		Corner of Turfy Leas, Hedge to Turfy Leas.
	ag. 80	20	ag. 15	
	10	40		
		280		
	18	300	20	
		563		
Θ 2 in the Lane				
338°. 00'	B	338°. 00'		Hedge to Home- Close.
180. 00	<	161.50		
518.00	10	0		
356.10		20	ag. 17	
161.50		446		
Θ 3 in the Lane				
	B	1°. 30'		Orchard-Hedge
	>	203.30		
	20	0	10	
1°. 30"		41	ag. 10	
180 00		204	ag. 15	
181.30	Gate into Cow Pa- sture. Hedge to Ditto.	261	20	Gate into the Yard.
360.00		290	18	Corner of Barn
541.30				
338.00	20	388	ag. 24	Calves Croft- Hedge.
203.30		435		

Gate

Remarks	Offsets	Station Line	Offsets	Remarks
		⊙ 4 in the Lane		
	B	349° 30'		
	<	168.00		
	ag. 20	90		
	13	140		
		220		
Gate into Garrot Field, Hedge to Field.	16	500	○	on Stockin Hedge.
		626		
		⊙ 5 in the Lane		
	B	13° 50'		
	<	204.20		
	10	0	20	
		64	12	
	35	152		
	30	236	10	
		⊙ 6 in the Lane		
	B	93° 30'		
	<	259 40		
Corner of Stockin	○	10 int. into Stockin		
	6	270		
	3	500		
	40	750		
		⊙ 7 in Stockin		
	B	193° 30'		
	<	280.00		
Hedge to Wood	23	0		
	60	335		
	45	620		
	ag. 20	668		
		680		

Hedge

Remarks.	Offsets	Station Lines	Offsets	Remarks
		⊙ 8 in Stockin		
	B	229°00'		
	∧	215.30		
Hedge to Stockin	10	0		
	10	268		
		⊙ 9 in Stockin		
	B	268°30'		
	∧	219.20		
Corner.	30	22		
Hedge to Stockin				
		300	20	Close Stockin here
Hedge to Lane, in corner next to Calves Croft.				
		⊙ 9 ret.		
	B	192°00'		
	∨	143.00		
		20 int.		
		Into home Close.		
		90	20	Calves croft, Hedge
		220	20	Garden Pales.
		350	20	Corner of Orchard Hedge.
		361		
		⊙ 10 in Home-Close		
	B	264°40'		
	∧	252.40		
		205	0	on Orchard Hedge
		250	20	close here
		255		
Out-lines of Orchard, Garden, &c. close on Hedge next the Lane.				

Remarks.	Offsets.	Station Lines.	Offsets.	Remarks.
	B	⊙ 8 ret. 105°00'		
	∠	91.30		
		19 int.		
		into home Close.		
Hedge to Wood.	corner 5	24		
	37	353		
	28	465		
	B	⊙ 11 in Home Close.		
	∠	193°30'		
	60	268:30		
		130		
Hedge to	ag: 61	476		
home Close				
Corner	18	727		
	B	⊙ 12 in Home-Close.		
		259°00'		
		∠ 246:20		
	ag: 28	65		
	48	268		
		667		
		close here		
Close Home Close on Hedge to Lane, next Turfy-leas.				

Remarks.	Offsets.	Station Lines.	Offsets.	Remarks.
	B V	@ 12 ret. 189°, 20' 176, 00 20 int. into Crabtree close 60 612 618 int. into Charlton Field. 642	55 12	Corner Hedge to Turfy-lease. Corner.
	B V	@ 13 in Charlton Field. 262, 40 253, 20 10 510 530 reaches first Station.	28 20 close here.	Turfy-leas, Closes on Corner of Hedge next the Lane.
Touch on Hedge to Crabtree-close.	B V ° 17	@ 13 ret. 103°, 00 94, 00 135 310		
	B V 3 26	@ 14 in Charlton-Field. 69°, 00' 146, 00 320 545 618		

Remarks.	Offsets.	Station Line.	Offsets.	Remarks.
		⊙ 15, in Charlton Field.		
	B	5°, 00		
	<	116, 00		
	15	60		
		166 int.		
		Into Charlton Common.		
Hedge to	120	337		
Crabtree close.	16	563		
		645		
		⊙ 16 in Charlton-common.		
	B	276°, 35'		
	<	91, 35		
		16 int.		
		Into Crabtree-close		
		22	30 Hedge to Wood.	
		710 close here.		
		Close Crabtree Close on Corner next Home-Close and Wood.		
		⊙ 16, ret.		
	B	10°, 20'		
	>	185, 20		
	22	220		
	60	386		
	69	434		
A Gate into	50	611		
the Wood.	10	930		
	32	1110		
	86	1268		
	142	1353		
		1553		
		H 2		⊙ 17,

Remarks.	Offsets.	Station Line.	Offsets.	Remarks.
		⊙ 17, in Charlton Field.		
	B	264°, 30'		
	<	74, 10		
	128	225		
		318 int.		
	Into Clemenson's Land			
	56	370		
	25	504		
	12	784		
		1240		
Outwood Closes on Corner of Stockin, next to Clemenson's Field.				
		⊙ 6, ret. into Lane.		
	B	270°, 50'		
	<	77, 00		
		28 int.		
		33	10	Hedge to W. Green.
		288	40	
		560	10	
		932	98	corner to River.
		⊙ 18 in Garrot Field.		
	B	186°, 00'		
	<	95, 10		
	>	131, 10		Angle to a Bend in the River, from ⊙ 18.
		26	75	
	56	175	82	
	25	248	53	
		300		
		225	0	Touch the Rivers Brink
		422	145	
		536	110	
		620	116	

Remarks.	Offsets.	Station Line.	Offsets.	Remarks.
		Θ 19, in Garrott Field.		
	B	96°, 30'		
	<	90, 30		
		0	8	Hedge to Garrot Field
				continu'd to River.
		180	0	
		390	34	
		558	50	ag. Hedge to
				Cow-pasture.
		890	76	
		1024	50	close here.
Close Garrot-Field on Hedge next to Lane.				
		Θ 19 ret.		
	B	186°, 00'		
	<	180, 00		
		8 int.		
	Into	Magg-Meadow.		
		57	126	
		143	120	
		280	42	
		348	21	
		572	97	
		665	46	
		780	8	A Bridge.
		900	0	
		1004	25	
		1045		
H 3 Θ 20,				

Remarks.	Offsets.	Station Lines.	Offsets.	
		Θ 20, in Magg-Meadow.		
	B	151° 00'		
	∧	145, 40		
		78	40	
		154	82	
		280	75	
		395	30	Corner to River.
		Θ 21, in Magg-Meadow.		
	B	54° 30'		
	∧	83, 35		
		0		28 Hedge to Magg Meadow.
		100	64	
		245	78	
		380	59	
		452	27	
		Θ 22, in Magg-Meadow.		
	B	358° 00'		
	∧	123, 20		
		0	28	
		147	53	
		378	28	A Gate.
		600	6	
		790	30	
		890	60	
		1010	137	Close here.
		1032		
Magg-Meadow closes on the corner of the Hedge next Garrot-Field.				

Remarks.	Offsets.	Station Lines.	Offsets.	Remarks.
		⊙ 21, ret.		
	B	143°, 35'		
	<	172, 35'		
		22 int.		
	Into Cow-pasture			
		90	6	
		244	60	Corner to River
		⊙ 23, in Cow-pasture.		
	B	92°, 50'		
	<	129, 05'		
		205	55	Hedge to Cow-past.
		245	60	
		302	68	
		428	24	
		560	20	
		680	38	
		755	58	
		842	45	Close here.
		936		
Cow-pasture closes on Corner next Charlton-Field.				
H 4 S E C T.				

S E C T. II.

The manner of Protracting the Observations contained in the preceding Field-Book.

THE Protractor for this Purpose is best made a whole Circle, and marked on the Limb where the Numbers begin with *N.* or a *Flower-de-luce*, for then may that Part of the Protractor be kept always one Way as the Instrument in the Field, and therefore you will be less liable to mistake, than if you use a Semicircle, which must be laid upwards or downwards, as the Degrees of the Bearing are more or less than 180; and the Diameter of this Protractor is laid Parallel to the Meridians, by the Help of equal Divisions graved on the Protractor.

Being provided with a Sheet of strong Cartridge-Paper, or (if that is not large enough) a Skin of Parchment; or which I reckon better (especially for the fair Plott) if one Sheet of Paper be not big enough, to have several Sheets pasted on Cloth or Canvas well stretched and dried in a Frame before you use it; and this you may have of any Size, as the Largeness of the Work to be laid down requires.

Or a Practiser may have Sheets of large Paper printed from a Copper-plate, with fine Meridian-Lines drawn thereon at exact Distances, and these will be very neat and true, and will save much Trouble in drawing Meridian-Lines by a Parallel Ruler, or otherwise.

If you have not a Parallel Ruler, you may draw Lines parallel to one another, by setting one Foot of a Pair of Compasses at or near the End of your given right Line, and with the other describe the Arch of a Circle; do the same at
the

the other End of the Line, and through the utmost Convex of these Two Arches you may draw a Line Parallel to the first.

Having drawn Parallel Right Lines at convenient Distances throughout the Paper marked with N. S. representing Meridian, or North and South Lines, I pick out some Place in one of these Lines, to represent the first Station, as at $\odot 1$, Fig. 22, and lay the Center of the Protractor on the Point $\odot 1$, the Diameter being Parallel to the Meridian Line, and the Beginning of the Degrees of the Protractor towards N. or upwards; and because the Bearing of the first Station Line is $356^{\circ} 10'$, I make a Mark with my Protracting Pin against that Number, close to the Limb of the Protractor, to which Mark I draw an obscure Line from $\odot 1$, representing the Chain Line from $\odot 1$, to $\odot 2$.

Then the Field-Book being open before me, I lay the Edge of my Plotting-Scale to this obscure Line $\odot 1$ and $\odot 2$; and because I find in the Field-book that the Offsets from this Line were laid off at 20, 40, 280, 300, and 563; therefore making the Beginning of the Numbers on the Plotting-Scale to coincide with $\odot 1$, I make a Prick against each of these Numbers, close to the Edge of the Plotting-Scale; and then turning the Scale perpendicular to the Line, I apply it successively to those several Points, and there prick off the Length of the several Offsets on the respective Sides of the obscure Line; so against the first Mark in the obscure Line, I prick off 15 Links to the Right, which gives the Corner of *Turfy-Leas*: Also against the second Prick in the obscure Line, I prick off 80 Links to the Left, which give the Corner of *Cow-pasture*; at 280, or the Third Mark in the obscure Line, I prick off 10 to the Left; at 300, 20 to the Right; and

and at the End of the Line 563 I prick off 18 Links to the Left: Lastly, I draw Lines with Ink from Point to Point on the Outsides of this obscure Line, thereby constituting the Bounders of the *Lane* so far.

At the first and second Distances, I was against the Corners of *Turfey-Leas* and *Cow-pasture*; therefore, with a Black-lead Pencil I draw Two short Lines, cutting the *Lane*, to denote that the *South Fences* come up to the *Lane* at those Corners, and will hereafter be of Use in closing these Plots.

Having thus finished my first Length, I produce the obscure Line, if Occasion requires, both Ways, till it is as long each Way as the Radius of the Protractor; then I place the Center of the Protractor on the Point $\odot 2$, and turn it about thereon, keeping the Beginning of the Degrees towards $\odot 1$; the last Station; till the Diameter coincides with the Station-Line $\odot 1, \odot 2$; then close to the Edge of the Protractor, right against $161^{\circ} 50'$, the Degrees of the present Angle, I make a Mark with my Protracting-Pin; and to that Mark from $\odot 2$, draw an obscure Line, representing the Station-Line, from $\odot 2$, to $\odot 3$.

And that I may be sure the Line $\odot 2, \odot 3$, is drawn in its true Position, I turn about the Protractor, the Center still coinciding with $\odot 2$, till the Diameter be Parallel with the Meridians; the Beginning of the Numbers of the Protractor being towards N. on the Meridian Line, and then will the Line $\odot 2, \odot 3$, before drawn, meet the Limb of the Protractor against $338^{\circ}, 00'$, the Bearing of the Line $\odot 2, \odot 3$, which proves the Line $\odot 2, \odot 3$, to be truly laid down.

And thus may the Plott be laid down by the Angles, and examined by the Bearings.

The

The constant Rule I observe in drawing the Angles is this: To lay the Diameter of the Protractor on that Line which brought me to the present Station, where the Angle about to be laid down, was taken; and to keep the Beginning of the Numbers on the Protractor towards the last Station.

And in Order to prove that each Angle is truly laid down, I turn about the Center of the Protractor on the Point, representing the present Station, till the Diameter be parallel to the Meridians, with the Beginning of the Numbers towards N. on the Meridian-Line; then will the Line last drawn, cut the Number, expressing its Bearing on the Limb of the Protractor, if that Line be drawn in its true Position.

In like Manner, I lay down and prove the Angles taken at the 3d, 4th, 5th, 6th, 7th, 8th and 9th Stations; and also the corresponding Lengths and Occurrences, continuing the Bounders to the several Offsets as I go along, drawing a short Line across them with a Black-lead Pencil, where the Remarks *a*, *g*, &c. are noted in the Field-book, breaking off the Fences where there are Gates: So at the last Length, from $\odot 9$, when I have drawn that Line in its true Position, and made it of its just Length, as noted in the Field-book, I find its Extremity to coincide with that Point in the Fence, to which I laid off an Offset from 388 in the Station-Line $\odot 3$, $\odot 4$, in the Lane, which proves that the Angles and Lengths enclosing the *Stockin*, are truly laid down.

But if the Extremity of the last Line does not coincide with the Extremity of the last Offset laid off from the Station-Line $\odot 3$, $\odot 4$, both denoting the North-west Corner of the *Stockin*, the Lines and Angles designed to enclose the same

Stockin,

Stockin, are not truly laid down, and therefore must be corrected before I proceed.

Next I lay the Protractor on $\odot 9$, the Diameter coincident with the Line $\odot 8$, $\odot 9$, being the same Line which brought me to that Station; and having laid down the Angle, $\odot 8$, $\odot 9$, $\odot 10$, I prick off the several Offsets, marking them as the Field-book directs, where the Lines of Partition within come up to the Hedge.

Having drawn the Chain-Line from $\odot 10$, and set off the last Offset therefrom 20 Links, I find the Extremity of that Offset to coincide with the Mark I drew cross the Fence at the 2d Offset from $\odot 3$, which proves the Work to be truly laid down.

The Out-Lines round the Orchard, Garden, Yard, &c. being drawn, the Angles within, about the Buildings, may be measured with a Bevel; or else with the Chain only, (as directed in the Use of the Chain) which, together with the Remarks on the Out-sides, will be an easy Direction for drawing the several Bounders within those Lines.

Having finished the Ground-plot about the Buildings, I find the next Station in my Field-book, marked $\odot 8$. *ret.* therefore I return to $\odot 8$, in my Draught, and lay down that Angle by the Line immediately preceding that Station, *viz.* $\odot 7$, $\odot 8$, and proceed to $\odot 11$, laying down the several Occurrences as noted in the Field-book.

The Rules I observe in these Cases, are, to number with Black-lead all the Stations I have already laid down in my Draught, and to express those Numbers successively one after another, in a Piece of a waste Paper.

If the Number of the present Station doth not immediately succeed that of the last, but is greater by an Unit than any of the Numbers in the waste

waste Paper, then I lay down the Angle of the present Station with the Line I measured immediately before I came to it, and number it as in the Field-Book.

But if the Number of the present Station is greater than any in the waste Paper by more than an Unit, there hath been some Omission in the waste Paper, which must be rectified.

If I come to a Station whose Number is already entred in the waste Paper, then I return to that Station in my Draught, and there lay down that Angle with the Line measured, immediately before I came to this Station the first Time.

Thus observing these Directions, may the Plot be laid down without any Burthen at all to the Memory; and if it was surveyed by one Man, it may be plotted by another, provided the Person who surveyed it did observe these Rules; and any Method of keeping a Field-book, that lays a Burthen on the Memory, is imperfect, and not fit for Practice.

The remaining Part of the Work is reserved for the Exercise of the Reader: The Plan thereof was here laid down by a Scale of $\frac{1}{4}$ of an Inch: I sometimes lay down the Plot of each Field by a Scale of half an Inch or larger, if the Plot will lie on one Sheet of Paper, and cast up the Content of each separately by that Scale; and for this Purpose, the Sheets with Meridians ready printed thereon, are very serviceable, though I afterwards lay down the whole Plan together by a Scale of a Quarter of an Inch or less, entring the Content of each Field, as cast up by the large Scale in the Middle thereof.

S E C T.

S E C T. III.

Of Reducing Plots.

THE Plot of a Manor or Lordship consisting of several Hundred Acres lying together, being laid down by a Scale of a Quarter of an Inch or less, may yet be larger than is desired, and therefore must be reduced into a lesser Compass. Now for the Performance of this Work there are several Instruments, as, a long Scale made with a Center-hole at One Third Part thereof; so that Two Third Parts may be numbred one Way with equal Parts, from the Center-hole to the End, and the other Third Part numbred the other Way with the same Number of equal Parts, though less according to what Proportion you please; but to pass by this, and several others, I shall only give an Instance of the Parallelogram, which for Generality, Exactness and Dispatch surpasseth all others, and is commonly made of Six Wooden Rulers joined together, and supported by Brass Feet, with Holes in the Rulers for setting the Instrument to certain Proportions.

But I have lately seen one of these Instruments made of Brass in a different Form from the other, and much better, because it may be set to any given Proportion whatever, by the Help of Sliding Centers, that are moved along certain Lines calculated for that Purpose, and divided on the Sides of the Parallelogram; so that a Plott may be reduced with the utmost Exactness to any given Ratio, in Respect of the former, either in Proportion, as the Length of the Sides of the foul Plott shall be to the fair one, or else as the Area of the one to the Area of the other; and another Thing may be said of this Instrument, that

that Curves are as well reduced thereby as Right-Lines; which by any other Instrument is exceeding difficult, if not impossible to be done.

The Parallellogram being fixed upon a very smooth and even Table, and the foul Plott, and fair Paper fastened thereon, one over-against the other, set the Parallellogram to what Proportion you would have your reduced Plott be of, in Respect of the former; then bring the Point of the Tracer to one of the outmost Angles of the foul Plott, and put in the Point which is to draw, in its Place, letting it rest on the fair Paper; then move the Tracer with a gentle, equal Motion, over all the Lines of the foul Plott; so shall the Motion thereof occasion the Drawing-Point to draw upon the clean Paper or Parchment, the true and exact Figure of the former Plott, tho' of another Bigness, according to what Proportion you set your Instrument; which will better appear by seeing the Instrument once used, than Words can possibly explain.

When you have gone round the Lines that enclose one Field, you may take out the Drawing-Point, and bring the Tracer to any other Point on the foul Plott; then put the Drawing-Point in its Place again, and proceed on with your Work.

Note, This Instrument is useful, not only for this Purpose, but also for Copying any small Print, &c. in Miniature. But for Reducing great Plotts of Land, it should be made of a larger Size than is commonly used for other Purposes.

S E C T.

S E C T. IV.

Directions for Beautifying and Adorning of Plotts.

HAVING reduced the Plan of the Lordship, Manor, &c. to the intended Bigness; 'tis necessary to draw imaginary Lines both vertical and horizontal, denoted by Letters at the Top and Bottom, and also on the Sides, to be referred to by the Table of References, for the ready finding of any Field or Parcel of Land therein contained, such as you will find in the new Maps of London, &c.

The *North* Part of the Plott is always supposed to be placed upwards, and the *East* to be on the Right Hand,

The Representation of Hedges ought to be laid down on the same Side of the Fences that they are in the Land, and to be broke off where there are to be Representations of Gates.

The Out-Borders of the Plott, at least such as border next to the Demesnes, ought to be fill'd with the adjacent Hedges, and the Tenants or Owners Names of the Grounds.

If you describe all Rivers, Highways, Windmills, great 'lone Trees, Gates, Stiles, &c. that fall within your Plott, it will add to the Beauty thereof.

The Ground-Plott of Buildings, ought in all Cases to be expressed by the same Scale that the rest of the Plott was laid down by, and to be taken Notice of in the Table of References; but never go about to draw the Representation of an House or Barn in the Midst of the Plott, so big as will cover an Acre or two of Land.

But

But if you would expresse a Gentleman's Seat, or Manor-house, 'tis best done in some Corner of the Draught, or in a Plan by itself, annex't to that of the Estate to which it belongs. And the House must be drawn in Perspective, (as you will be shewed hereafter) and if the Gardens, Walks and Avenues to the House are expressed, it must be in the same Manner; and where there are Trees, they must be shadowed on the light Side.

If you will take the Pains, you may, in one of the upper Corners of the Plan, draw the Mansion-House, &c. in the other the Lord's Coat of Arms, with Mantle, Helm, Crest and Supporters, or in a Compartment, blazoning the Coat in its true Colours: In one of the Corners at the Bottom, you may describe a Circle, with the 32 Points of the Mariners Compass, according to the Situation of the Ground, with a *Flower-de-luce* at the North Part thereof, ever allowing the Variation of the Needle: And in the other Corner, make a Scale equal to that by which the Plott was laid down, adorning it with Compasses, Squares, Ovals, &c.

Having wrote the Name and Content of each Close about the Middle thereof, you may, about the Bounds of each Field or Enclosure, with a small Pencil and some transparent Colour, neatly go over the black Lines; so shall you have a transparent Stroke or Margin on either Side of your black Lines, which being shadowed, will add a great Lustre and Beauty to the Plott.

If you would have your Fields all coloured, it will not be amiss to pounce over the Paper or Parchment with some Stanish-Grain and burnt Allom, and a double Quantity of Rosin, finely searced and lightly pumiced, to preserve the Paper from being pierced through with the Colours;

lours ; or wet it over with Allom-Water, which will add to the Lustre of the Colours.

Then lay on the Colours in Manner following, being first ground, and bound with Gum-Water very thin and bodiless: Arable for Corn, you may wash with pale Straw-Colour, made of yellow Oker and White-lead ; for Meadows, take Pink and Verdigrease in a light green ; Pasture in a deep green of Pink, Azure and Smalts ; Fenns, a deep green ; as also Heaths of yellow and Indico ; Trees, a sadder green, of White-lead and Verdigrease ; for Mudd-Walls and Ways, mix White-lead and Rust of Iron, or with Okers brown of *Spain* ; for white Stone, take Umber and White, Water or Glasse may be shewn with Indico and Azure or Black-lead ; for Seas, a greenish Sky-Colour, of Indico, Azure, Smalts, White-lead and Verdigrease.

Having washed your Pencil very clean, take a small Quantity of the Colour, and on the Inside of the bounding Line draw the Colour along, of an equal Breadth, as near as you can, broader or narrower as the Field is in Bigness ; and having gone round the Field in this Manner, swill the Pencil in fair Water, and strike along the Inside of the coloured Line, bringing it more down towards the Middle of the Field ; and this will soften your Colour, and make it shew as if it lost itself by Degrees to the very Colour of the Paper : Lastly, with a Pen take some of that Colour which shadoweth the Colour you laid on the Field, and go over the Black-lead Line only ; so shall your Field be finished.

In this Manner, you may make 100 Fields in one Plott, of divers Colours, observing, as near as you can, not to colour Two Fields adjoining to one another of the same Colour ; and therefore it will be convenient to understand what Colours
best

best set off one another ; and as near as you can, lay the Enclosures adjoining to one another, of Two such Colours, that one Shadow may serve both.

This Colouring and Adorning of Plotts, is rather the Painter's Work than the Surveyor's: Yet if he has Time to spare, and Patience to finish the Work, it may prove a pretty Diversion: But for general Practice, I would recommend the Use of *Indian-Ink*, which ground very fine upon a smooth Tile, and the Hedges or Bounders of each Field shadowed therewith, will look very neat, and make the Plott resemble one done from a Copper-Plate, if rightly managed.

The Water-Colours before-mention'd, you may have in Shells ready prepared (being much readier than to trouble yourself with Grinding, &c.) as also the *Indian-Ink*, Pencils, &c. at Mr. Key-ton's, a Colour-Shop, in *Long-Acre, London.*



CHAP. V.

Shewing how to measure any Piece of Land, by the Chain only.

THE Content of any Piece of Land may be found, or a Plott thereof made, by the Chain only: So that if a Person is not furnished with Instruments more artificial, he may work with the Chain only in the following Manner, though it be somewhat laborious and tedious.

S E C T. I. *Let. Fig. 23. be the Representation of a Field, whose Content in Acres is desired, without any Plott thereof.*

First, I walk about it, and set up Marks at the several Angles, *a, b, d, e, g, h, k, l, n*, viewing (as I go along) from which Angle to which Angle it will be most convenient to run a Diagonal or Base Line, as the Line *a, g*; so that a Perpendicular from the opposite Angles, as *b* and *n*, may fall upon this Diagonal or Base, in a convenient Manner at Right Angles: And *note*, we commonly chuse the longest Line between any Two opposite Angles that form the Trapezia or Triangle, to be the Base Line.

Having

Having a Sheet of Paper in Readiness, on which to draw an Eye-Draught of the whole Work, I make some Remark near the Angle, at a , and lay the Chain thereto, stretching it in a strait Line towards the opposite Angle g ; then I draw a strait Line on the Paper, to represent the Line a, g , which I am about to measure; and proceed with the Chain towards the Angle g .

When I have measured 4 Chain on the Line a, g , I perceive my self almost over-against the Angle b , therefore having laid the Chain a Fifth Time, I set down an Arrow at the End of the Chain next g , and let it lie on the Ground in the Direction of a, g , and then endeavour to find a Point in the Base a, g ; from which, a Right Line measured in the Angle b , may stand at Right Angles upon the Base a, g .

For this Purpose I provide a small Brass Cross, with four plain Sights thereon, having a Socket on the Backside, which I put on the Head of a short Staff, and set the Staff in the Ground close to the Chain; then I set two of the Sights in the Direction of a, g , by looking backwards and forwards through those Sights till I can see the Mark in each Angle a and g ; so shall the Mark in the Angle b , be seen through the other Two Sights, if the Staff be set in a Perpendicular from b , but if not, I move the Staff backwards and forwards by the Side of the Chain, in the Line a, g , till through Two of the Sights I see a and g , and through the other Two the Mark at b ; then will the Staff be set in the Point c ; and this is the exactest Way.

But if you have not such a Cross, get a Bit of Board made exactly square, in Form of a square Trencher, and from Corner to Corner draw strait Lines thereon; and stick a Pin fast and upright in the Line near every Corner, and make an Hole

in the Middle of the Board, so that you may turn it on the Head of a Staff; this, for once, may supply the Want of the Cross.

Having found the Point c , in the Line a, g , there set down a Staff, and take Notice how many Chains and Links it is distant from a , viz. 418, therefore I apply a Scale to the Right Line on my Eye-Draught, and near 418 make a Mark at c , but don't regard whether it be exact or no, so it be within 20 or 30 Links, because the true Lengths of each Line are measured on the Ground.

Then I measure on the Ground, in a strait Line, the nearest Distance between c and b 600 Links, and erect a Perpendicular on the Point c on the Paper, as near as I can guess, by applying the End of the Scale to the Line c, a , and by the Edge thereof draw the Line c, b , setting close thereto 600 Links, the Length of the Perpendicular; but don't regard whether the Line c, b , on the Paper, be made of its just Length or not, but only that the Form of the Eye-Draught may be something like that of the Field, a Resemblance thereof being all that is requisite in this Case.

Next I return to the Arrow, and measure forwards on the Line a, g , till I am near against the Angle n ; and by a few Trials, I find the Point o , at the Distance of 616 Links from a ; and then measure the Perpendicular o, n , setting the true Length thereof 368, close to its Representative on the Eye-Draught.

Now I look towards the Fences a, b , and a, n , and because they are strait Lines, I draw b, a , a, n , on the Eye-Draught, so is that Side of the Field finished.

From o , I proceed with the Chain in a strait Line to g , and find the whole Length from a to

g, 1375 Links; which I set close to the Right Line on my Eye-Draught.

Then I make that Right Line on the Paper nearly the Length of 1375, and draw the Right Lines g, b , and g, n , cutting the Ends of the Perpendiculars c, b , and o, n ; so shall the greatest Part of the Field be expressed on the Paper, by the Trapezia, a, b, g, n .

From g , I measure in a strait Line towards d , and when I come to f , I measure the Perpendicular f, e , 60 Links, and then measure out the Line g, d , to d 800 Links, and draw the Lines g, e, e, d , on the Eye-Draught, to the Extremity of the Perpendicular f, e . Now I number the Angles round the Field, if I can see the Marks at each, and compare 'em with those on the Eye-Draught, and thereby discover what Part of the Field I have already measured, and what remains to be done.

In the same Manner as I measured the Triangle g, d, e , I measure the Triangles g, b, k , and k, l, n , and then if there be so many Angles expressed on the Eye-Draught, as there are Marks at each Angle round the Field, and if the true Length of each Base and Perpendicular, as measured in the Field, be expressed on the Representative of the Eye-Draught, you may proceed to cast up the Work.

The same Lines in the Field, *Fig. 23*, are measured on the Land with the Chain, as we should have done on the Paper, with the Scale, if the true Plott of the same Field had been first made by the plain Table or other standing Instrument; and therefore must be cast up in the same Manner; for you have the true Length of each Base and Perpendicular given on the Eye-Draught; so the Sum of the Two Perpendiculars c, b , and N, o , multiplied by the Base a, g ; also the Bases and

Perpendiculars of the other three Triangles multiplied together, and added into one Sum, the half of that gives the Content of the Field, *Fig. 23*, in square Links, which reduce in Acres, &c. as directed in Chap. I.

This is the best Way I can prescribe, for finding the Content of a Field by the Chain only, without making a Plott thereof, and is only proper for plain, level Ground, and small Enclosures: But even then, if the Fences are very irregular, 'tis better to go round and measure the Angles by the Chain, taking Offsets from the Station-Lines to the Fences.

Indeed if the Fences be tolerably regular (but there are many Fields, whose Sides are not so strait as *Fig. 23*.) you may make a true Plott thereof well enough, by observing at how many Chains and Links the Perpendiculars meet the Base of the Triangles or Trapezias, by erecting Lines on those Points Perpendicular to the Base, which made of their true Lengths, as measured on the Ground, the Sides of the Field may be drawn from the Extremities of the Base, to the End of each Perpendicular. Also observe, if any of these Bases be longer than 10 Chains, leave a Staff at the Tenth, and take the Direction of the Line by that Staff, because the Station will be at too great a Distance; and if the Length be 20, set up another Staff, and so on.

S E C T.

S E C T. II.

How to measure Angles by the Chain.

TO this End provide Three round Station-Staves, four or five Foot long a-piece; and also take Care that the Ring in the Middle of the Chain, and also those at each Tenth Link be at their due Distance from the Chain's End.

1. In order to measure the Angle d, o, e , *Fig. 24*, set one of your Station-Staves as upright as you can at o ; and putting the Ring at one End of the Chain over it, let one of your Assistants take the other End in his Hand, and stretch out the Chain towards d , whilst you standing at o , direct him to move side-ways till the Station-Staff which he has in his Hand, be brought into one Right Line with o, d , as at a , and there let him leave the Staff.

Then let him, with the End of the Chain in his Hand, move towards e ; and as before, direct him to plant the Third Staff upright in the Line o, e , at b .

Measure the Distance a, b , in Links and Tenth Parts, if less than one Chain, and enter 'em in the Field-Book 88 $\frac{1}{2}$.

When you plott this Angle, take with a Pair of Compasses from a large Scale, the Distance of one Chain; and having drawn a Right-Line d, o , set one Foot of the Compasses in o , and with the other describe an Arch a, c ; then from the same Scale take 88 $\frac{1}{2}$ Links; and setting one Foot of the Compasses at a , let the other fall in the Arch a, c , and make a Mark at b : Lastly, through this Mark, from o , draw the Line o, e , constituting the Angle d, o, e .

Observe

Observe to plott your Angles by a large Scale, as an Inch, or two Inches, and the Length of the Sides by a smaller, as a Quarter or Half an Inch: Also observe, that when the Length of the Chord a, b , is longer than one Chain, then 'tis best to lay out a Sextant, or two Sextants, in the following Manner.

2. The Manner of measuring Angles with the Chain, by laying of Sextants, is deduced from this known Property of the Circle, *viz.* *The Radius of every Circle is equal to the Chord of One Sixth Part (or a Sextant) of its Periphery.*

Let it be required to measure the Angle b, a, c , Fig. 25: First, set up a Staff at a , and lay the Chain strait in the Direction of a, b , to i , and at 50 Links set down an Arrow at o ; then let your Assistants hold the Ends of the Chain at o , and a , whilst you with the Middle in your Hand, laying both Halves strait, set down an Arrow at e , constituting the equilateral Triangle o, a, e ; so have you laid out the Angle o, a, e , a Sextant.

But if you have two Chains, you may (which is better) lay out the Sextants, so that each Side of the equilateral Triangle be one Chain.

Now the Chain's End still held at a , stretch it through the Point e to d , where also set down an Arrow: Lastly, measure the Distance from the Arrow at d , to a Staff set up one Chain's Length from a at u ; so shall the Distance d, u , be 76 Links, and Four Tenths of a Link; Therefore enter in the Field-Book 1^s. 764^p. implying 1 Sextant and 764 Parts.

In order to plott this Angle, b, a, c , thus measured, chuse some Line divided into 1000 Parts, and making this Line Radius, set one Foot of the Compasses in a , and with the other describe the Arch, i, z ; and the Compasses continuing at the

the same Extent, set one Foot in i , and with the other, cross the Arch at d , and there make a Mark.

Then take 764 Parts from the same Line, divided into 1000 Parts, which you made Radius; and set one Foot of the Compasses in the Mark at d , and let the other cross the Arch at u , and there make a Mark: Lastly, from a , draw a Line through the Mark at u , and you will construct the Angle required.

If you have not a Line (which is best) actually divided into 1000 Parts, use the largest Diagonal Scale you have; so you may take off 76 Parts exactly; and the four Tenths you must guess at by moving the Compasses near half way in the Diagonal towards 77; also observe, the 10th of a Link is measured on the Land by the Offset-Staff, having a Link or two thereon, divided into Ten Parts.

3. If the Angle be more than Two Sextants, as in *Fig. 26*; then having, as before, laid off the Sextant e, o, a , let your Assistants hold the Ends of the Chain at a and e , while you with the Middle in your Hand, set down an Arrow at x , constituting another Sextant e, a, x .

Then the Chain being held at a , lay it thro' x , and at the other End d , set down an Arrow: Lastly, measure d, u , which suppose to be 42 Links and 5 Tenths; therefore enter in the Field-Book 2^s, 425^p, signifying 2 Sextants and 425 Parts.

And if you would protract the Angle of *Fig. 26*, then with the Length of the Line divided into 1000 Parts, describe the Arch i, y , and thereon lay i, n , and n, d , each equal to the Radius or divided Line; and afterwards lay 425 equal Parts from d , to u , and draw a, u ; which gives the Angle, as required.

Observe,

Observe, if you were about to measure the Angle, *Fig. 26*, and had set up one of your three Staves where the Station-Lines meet in the angular Point *a*, another at *i*, and the other at *u*, in the Lines *a, b*, and *a, c*; before you proceed to measure the Angle *i, a, u*, you must be sure that the Staves at *a*, and *i*, and the Mark at *b*, are exactly in the same Plane; and also the Staves at *a*, and *u*, and the Mark at *c*, in another Plane.

So when the Staff at *a*, is planted as nearly Perpendicular as you can, move yourself backwards, the farther the better, 'till you see the Staff at *a*, and that at *i*, in one strait Line with the Mark at *b*; there stand, and direct your Assistant to place his Staff, so that the Staff at *a*, exactly cover that at *i*, from the Top to the Bottom.

S E C T. III.

Observations on Working with the Chain.

IF you would continue a strait Line, you may signify it, by entring in the Field-Book 3^s. 000, that is, 3 Sextants.

If an Angle be external, and so contain more than 3 Sextants, as *b, a, c*, *Fig. 27*, put the Ring at one End of the Chain over the Staff at *a*; and taking the other End in your Hand, stretch out the Chain at Length towards *d*, and move Sideways, till you perceive yourself in a Right-Line with *a, b*, and there at the End of the Chain, set down an Arrow at *d*, so that *d, a, b*, are in the same Plane, and then set down the other Staff at *c*, at the End of one Chain also; so that the Staves at *a*, and *c*, be in the same Plane with the Mark at *e*. Now measure the Angle *d, a, c*, in the

the same Manner as aforesaid, and to it add the Sextants, so will the Sum be the Measure of the external Angle d, a, c .

So if the Angle d, a, c , be 947, then will the external Angle b, a, c , be 3 Sextants, 947 Parts; and if the Angle d, a, c , be $1^s. 947$, then b, a, c , will be $4^s. 947$, &c.

When you protract the external Angle b, a, e , first continue the Line b, a ; then from the Angle subtract 3 Sextants, and make the Angle d, a, e , equal to the Remainder.

2. But if you go on the Outside of a Field or Wood, you may then work as though you were within the Wood, by measuring the Angle vertically opposite to those that are internal: So in *Fig. 28*, if you measure the Angle o, a, u , instead of b, a, e , it will do your Business when you come to protract, as well as if you had measured b, a, e , on the Inside; for if two Right-Lines cross one another, the contrary or vertical Angles are equal. *Euclid. 15. 1.*

Angles measured by the Chain, may be laid down by a Protractor made on Purpose, having Sextants and Links divided thereon; and then to be used in the same Manner as other Protractors.

The Manner of keeping the Field-Book, is in all Respects the same as those used in the 2d, or 4th Chapters, except that when the Angles are measured by the Theodolite, you note the Quantity of each by Degrees and Minutes: In this Case, when measured by the Chain, you note the Quantity by Sextants and Parts.

So if you were to measure the Field, *Fig. 14*, by the Chain, instead of noting $102^{\circ}, 20'$, for the Quantity of the Angle b , you must note 1 Sextant 734 Parts; and instead of $230^{\circ}, 50'$, for the external Angle d , you must note 3 Sextants, 886 Parts;

Parts ; but the Station-Lines, Offsets, &c. will still be the same.

There are other Ways of Working with the Chain ; but these before-mention'd are the best and exactest, and contain as much Variety as any one will commonly put in Practice : Also thereby you might measure an inaccessible Distance, and do several other Things ; but these are only for a Shift, when we have no other Instruments : And the same may be said of measuring Angles.

S E C T. IV.

Observations on measuring Land in Common-Fields.

WHen ploughed Lands in Common-Fields are measured by the Chain, 'tis usual to measure the Length down the Ridge of the Land, and to take the Breadth at the Top of the Land, about the Middle, and at the Bottom ; and adding these Three Numbers together, to take the Third Part of the Sum for the mean Breadth ; but 'tis not adviseable to take the Breadth very near the Lands Ends, because the Turning of the Plough generally makes it considerably narrower or wider ; and if in measuring down the Land, you find the Breadth is not nearly equal, 'tis best to measure cross the Land oftener, as at every 3 or 4 Chains Length, and adding the several Breadths together, divide that Sum by the Number of Breadths, for the equated Breadth : And for this Practice, half the Four Pole Chain is most convenient, remembring either to set them down as whole Chains, or to make 'em so, when you cast up the Content.

The

The several Furlongs in Common arable Fields, may be accounted as so many particular Enclosures, and measured after the same Manner, by setting up Marks at the Extremities of the Furlong, and measuring the Angles by the Theodolite, as before directed; and as you pass along the Station-Lines, you may from thence take Offsets to each Man's particular Lands; and against that Offset write the Name of the Owner or Tenant: And when you plott that Furlong, you may, by those Directions in your Field-Book (if you will take the Pains, which is not a little) express each particular Land in your Draught, with its Buttings and Boundings (but the Buttings and Boundings of Land in Common-Fields is necessarily expressed in all Cases): An Example of this is needless, only it may be added, that in the Survey of a large Common-Field, 'tis safer to divide it in Parcels, as separate Fields, keeping good Marks at the Stations, than to venture the Closing of the Plott, by going round it all at once, and dividing it into Parcels afterwards.

CHAP.



C H A P. VI.

*The Manner of Laying-out, or
Dividing Land.*

S E C T. I.

P R O B L E M I.



IF any Quantity of Acres be given, to be laid out in a Square Figure, annex to the Number of Acres given 5 Cyphers, which will turn the Acres into square Links; then from the Number thus encreased, extract the Square Root, which shall be the Side of the proposed Square.

So if you would cut out of a Corn-Field one square Acre, add to 1 five Cyphers, and then it will be 100000, the Root of which is 3 Chains, 16 Links, and something more for the side of that Acre.

Problem 2. If you would lay out a given Quantity of Acres in a Parallelogram, whereof one Side is given. — First, turn the Acres into square Links, by adding 5 Cyphers; and divide that Number thus encreased by the given Side, the Quotient will be the other Side, as if 100 Acres was to be laid out in a Parallelogram, one Side whereof shall be 20 Chains; therefore to the 100 Acres I add 5 Cyphers, which divided by 20 Chain, the
Length

Length of the given Side, the Quotient is 50 Chains for the Length of the other Side.

Problem 3. If you would lay out a Parallelogram that shall be 4, 5, 6, &c. Times longer than it is broad. First, turn the given Quantity of Acres into Links, as before, which Sum divide by the Number given, for the Proportion between the Length and Breadth, as 4, 5, 6, &c. the Root of the Quotient will shew the shortest Side of such a Parallelogram: As if it was required to lay out 100 Acres in a Parallelogram that shall be 5 Times as long as broad; first, to the 100 Acres add 5 Cyphers, and it makes 10000000; which Sum divide by 5, the Quotient is 2000000, the nearest Root of which is 14 Chains, 14 Links, and that shall be the shortest Side of such a Parallelogram; and by multiplying that 14 Chains, 14 Links, by 5, shews the longest Side thereof to be 70 Chains, 70 Links.

Problem 4. If you would make a Triangle that shall contain any Number of Acres, being confined to a certain Base: First, double the given Number of Acres, to which annex 5 Cyphers, and divide that Sum by the Base, the Quotient will be the Length of the Perpendicular: As if the Base given, be 40 Chains, upon which I am to make a Triangle that shall contain 100 Acres; first, I double the Number of Acres, and annexing 5 Cyphers thereto, I divide it by 40 Chains, the limited Base, so shall the Quotient be 50 Chains; for the Height of the Perpendicular, which I set on any Part of the Base, and from the Extremities thereof, draw the other Two Sides, which shall form the Triangle required.

So if when you are laying out a new Piece of Land of any given Content, altho' you meet in your Way with 100 Lines and Angles, yet you

may, by making a Triangle to the first Station you began at, cut off any Quantity required.

S E C T. II.

Of Dividing Lands.

E X A M P L E I.

SUPPOSE it was required to divide *Fig. 29*, whose Content is 10 *A.* 3 *R.* 22 *P.* into 2 equal Parts, by a Line drawn parallel to *a, b*.

First, the Acres, Roods and Poles must be reduced into square Links, which may be done thus :

If the Roods are $\left\{ \begin{smallmatrix} 1 \\ 2 \\ 3 \end{smallmatrix} \right\}$ add $\left\{ \begin{smallmatrix} 40 \\ 80 \\ 120 \end{smallmatrix} \right\}$ to the Poles,

and to the Sum annex 4 Cyphers ; divide this last by 16, and write the Quotient Figures, if they be 5, after the Acres. But if the Quotient

Figures are but $\left\{ \begin{smallmatrix} 4 \\ 3 \end{smallmatrix} \right\}$ write $\left\{ \begin{smallmatrix} 1 \\ 2 \end{smallmatrix} \right\}$ Cypher after the Acres, and then the Quotient Figures ; so will you have the square Links required.

Therefore 10 *A.* 3 *R.* 22 *P.* reduced into square Links, will stand thus :

$$\left\{ \begin{array}{c} 120 \\ 16 \end{array} \begin{array}{c} 1420000 \\ (88750) \end{array} \right\} \text{Square Links--} 1088750$$

Having reduced the Acres, &c. into Square Links, they make 1088750, the half of which is 544375, next draw a Line by guess parallel to *a, b*, as the Line *c, d*, and then cast up the Content of the Figure *a, d, c, b*, which suppose 494375 Square Links less than 544375, by 50000 Square Links, which shews that the Partition-Line must be set forwarder from *b, a*.

Now

Now, in order to know how much c, d , must be set forwarder, I divide the Excess 50000 Square Links by the Length of the Line c, d , 953 Links, and it quotes 52 Links; therefore from c , I set off 52 Links, and draw the Line f, e , parallel to b, a , and it will be sufficiently near the Partition-Line.

This is performed by the second Problem of the last Section; but if those Parts of the Boun-
ders c, f, d, e , be not nearly parallel, then 'tis best to draw a Triangle to c, d , instead of the Parallelogram c, f, d, e .

But if c, d , had cut off the Quantity a, d, c, b , greater than that required, then the Partition-Line had been more towards a, b , whose Distance might be found as before.

Examp. 2. Suppose it was required to cut off from *Fig. 30*, 6 Acres towards g, f , by a Line drawn from a given Point in the Bounder g, a , at a .

First, reduce the given Quantity, 6 Acres, into Square Links, and they will be 600000; and then draw the Line a, b , by Guess, from the given Point a , and cast up the Content of g, a, b, f , which amounts to 431680 Square Links, which is too little.

Next draw the Line a, e , from the Point a , forming the Triangle a, b, e , whose Content is 235600, which added to the Part g, a, b, f , amounts to 667280, which is more than the given Quantity 600000, by 67280 Square Links; therefore the Partition-Line passes between e , and b .

Now divide the Excess 67280, by 380, half the Length of the Perpendicular a, c , in Links, the Quotient is 77 Links, which set off from e , towards b , and draw a, d , which is the true Line of Partition.

Examp. 3. Suppose *Fig. 31*, was to be divided equally amongst Three Tenants, in such Manner that the dividing Lines may pass through the Pond *o*, in the Middle of the Field, so that each Tenant may have the Benefit of the Water.

First, Reduce the whole Figure into Square Links, and it will be found to contain 1477410; then each Tenant must have One Third Part thereof, *viz.* 492470 Square Links.

From *o*, to any Two Angles, as *a*, and *b*, draw the Lines *oa*, *ob*, forming the Triangle *a, o, b*; which being cast up, amounts to 291984 Square Links, which is too little.

To the next Angle *f*, draw *of*, forming the Triangle *a, o, f*, which being cast up, amounts to 231000 Square Links, which added to the Triangle *a, o, b*, gives 522984, which exceeds the Quantity required by 30514 Square Links.

Divide the Excess 30514, by 347, half the Length of the Perpendicular *o, g*, and lay the Quotient 87, from *f*, to *b*, and so shall *b, o, b, a, g*, be One Third Part of *a, b, c, d, e, f*.

Next draw the Line *oe*, to the next Angle *e*, and cast up the Content of *o, e, f*, amounting to 256410 Square Links; to which add the Triangle *b, o, f*, 30514 Square Links, the Sum is 286924, which is too little.

Therefore draw *od*, to the next Angle *d*, and cast up the Content of *o, e, d*, 265500 Square Links, to which add *b, o, e, f*, 286924, their Sum is 552424 Square Links; which is more than the Third Part of *a, b, c, d, e, f*, by 59954 Square Links.

Divide the Excess 59954, by 295, half the Length of the Perpendicular *o, i*, and lay the Quotient 203 Links from *d*, to *k*, and draw *ok*; so shall *Fig. 31*, be divided into 3 equal Parts, by the Lines *b, a, b, o*, and *b, f, e, k, o*, and *k, d, c, b, o*.

c, *b*, *o*, as was required; and the Pond *o*, laid out to each Tenant apart.

These 3 Examples express all the Variety that most commonly comes in Practice; for either the Partition-Line is required to be Parallel to some other Line assigned; or to pass through some given Point in the Fence; or to pass thro' a Point assigned in the Land.

If a Piece of Common was to be divided amongst several Tenants, in Proportion to the Rent which each pays for his Farm: The Numbers reduced to the lowest Denomination (except you express the Parts of Acres and Pounds by Decimals, which is better) the Rule is:

As the Sum total of all the Tenants Rent, is to the whole Number of Acres in the Piece of Land contained; so is each particular Tenant's Rent, to the Number of Acres to be laid out for his Part: This is very plain, and needs no Example.

So if a Piece of Common was to be enclosed, and divided amongst several Tenants, according to the Number of Beast-Gates which each Tenant hath in the Common, it is to be performed (*mutatis mutandis*) by the same Rule.

There is no Need of Direction how to make the Lines on the Land in the same Position as on the Paper-Plot, by carrying the Chain in a strait Line from Point to Point, on the Land it self, as divided on the Paper: Only take Notice, that the larger the Scale is, by which the Plott is laid down on the Paper, the exacter will the odd Links of each Line be estimated by the Scale, in order to transfer those Lines to the Land.

But if you are to divide a Wood, or very hilly Ground, so that you can't see the Marks from Side to Side, do thus:

Be sure to keep good Marks at every Station, as you measure round it, that you may find the

Hole at each, in which the Staff stood; then having plotted the Wood, and divided it on the Paper-Plott, in such Manner as desired, plant the Center of the Theodolite directly over that Point in the Station-Line on the Land where the dividing Line cuts it, on the Paper-Plott, and bring the Index to 360, or set it in the same Position as it was at the forward Station when you measured that Angle, turning about the Instrument, till the Hair in the Telescope cuts the last Mark; so that the Telescope be set exactly in the Direction of the present Station-Line, where the Dividing-Line cuts, and there screw the Instrument fast; then measure with your Protractor on the Paper-Plott, the Angle which the Dividing-Line makes with the present Station-Line; and turn about the Index on the Limb to the same Angle; so shall the Telescope be set in the Direction of the Dividing-Line; then by looking through the Telescope, you may cause Staves to be set up in the same Direction: And thus proceed in a strait Line, till you are far enough in the Wood, or quite through, if it be divided by one Line; but if by two Lines, you must continue them till they meet one another, as in the Paper-Plott.

The same Thing may be performed by the plain Table, or the Chain only; but those Instruments are not so convenient to measure a Wood, or hilly Ground, as the Theodolite.

S E C T. III.

How to reduce Customary into Statute Measure.

IF you would change Customary into Statute Measure, & *è contra*, the Rule is : As the Square of one sort of Measure is to the Square of the other, so is the Area of the one, to the Area of the other.

In some Parts of *England*, they account 18, in some 20, 22, &c. Feet to a Pole or Perch, and 160 such Perches to make an Acre, which is called customary Measure ; whereas our true Measure of Land, by Act of Parliament, is but 160 Perches to an Acre, accounting 16 Feet and an half to the Perch.

So if a Field measured by a Perch of 18 Feet, accounting 160 such Perches to the Acre, doth contain 100 Acres, how many Acres shall the same Field contain by the Statute Perch of $16\frac{1}{2}$ Feet ? Say, As the Square of 18 Feet, (*viz.*) 324, is to 100 Acres, so is the Square of $16\frac{1}{2}$ Feet, (*viz.* 272, 25,) to 119 $\frac{2}{5}$ of an Acre Statute.

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C H A P.



C H A P. VII.

*General Observations touching the
Surveying and Plotting of Roads,
Rivers, &c. With short Hints
how to make the Draught of a
County, or ground Plott of a City,
&c.*

IN this Seventh Chapter I have added general Directions for Measuring of Roads, &c. omitting particular Forms of Charts, as *fac similes*, which would take up more Room than can be spared in this small Tract; and indeed if the several Varieties that occur in these large and spacious Works were inserted, it would swell to a large Volume: But since the Surveyor's Judgment in contriving and carrying on his Work must be his best Guide; these few Observations may serve as Memorandums of the most necessary Things in Practice, which, together with other Rules before laid down in this Tract, may perhaps be a sufficient Instruction for the Performance of any Thing of this Nature.

S E C T.

S E C T. I.

General Directions for making a Draught of the Roads lying through any County, &c.

INstruments fittest for this Purpose are 1. the Theodolite as before described: The Angles which each Station-line on the Road makes with the Meridian, being observed by the Limb in the same Manner, as before described in Chap. III. and the Bearings of the several Remarks from thence by the Needle. 2. The Wheel or Way-wiser to measure the Length of the Lines, by driving the Wheel on the Road before you, so shall the Hands on the upper Part of the Instrument shew how many Miles, Furlongs, and Poles you go at one Time from any Station. 3. The Protractor as before described: A neat diagonal Scale of Brass and a good Pair of Compasses, or rather a Pair of beam Compasses, with such a Scale on the Beam as shall be agreeable to the Largeness of your Plott; for thereby you may lay down the Length of your Lines much exacter than by any other Way, by setting one Foot of the Compasses at one End of the Line, and moving the Socket on the Beam to one of the equal Divisions near the other End of the Line you are about to lay down, representing Chains or Furlongs; and then you may bring the Point of the Compass which stands perpendicular on the Paper to the Parts of that equal Division, representing Links or Poles by the Help of a small Screw, there being Divisions on the Edge of the Socket sliding close on the Beam according to *Nonus's* Projection; so that the Links of a Chain or Poles of a Furlong are estimated in the same Manner as the Minutes of a Degree
on

on the Limb of the Theodolite; for in these large Plans where the Distances of Places are determined by the Intersection of Right-lines from your Stations; those stationary Distances ought to be laid down as accurately as may be, for where a Mile is laid down in the Compass of an Inch, a Point is considerable.

In order therefore to make a Draught of the principal Roads that lye through any County, &c. first begin at some noted Market Town, or rather at the County Town, placing the Theodolite at some remarkable Church, &c. then having a Field-book with large Margins to enter the Remarks, and the middle Column representing the Station-Lines divided into three Parts, at the Head of each of which write *M.* for Miles, *F.* for Furlongs, and *P.* for Poles.

When you begin your Journey at the Top of the Field-book write the Name of the Place where you begin your Work, and making $\odot$ 1. in the Field-book to represent the first Station: Send some Person forwards on the Road, with a white Flag in his Hand, as far as you can see; and then by some known Sign cause him to stand; then bring the Index to 360, on the Limb, and turn the Instrument into the Direction of the Meridian, and there fix it; then direct the Telescope to the Person on the Road, and note the Degrees cut on the Limb for the bearing of the first Station-Line.

Put the Hands to the Beginnings of the Numbers on the Plate, and bring the Wheel to the Station, then cause one to drive it from the Place where your Instrument stood towards the Man on the Road, 'till you see some remarkable Object on either Side thereof; there let him stop and direct the Telescope to that Object, and note the Degrees which the Needle points to in the

the Box, and at what Distance the Instrument is planted from the last Station, together with the Name of the Object to which the Telescope was directed.

Having entered this in the Field-book, go on with the Wheel till you see something else remarkable on either Side of the Road; there stop and take a Bearing there; and in this Manner proceed till you come up to the Man at the second Station, observing as you go along on the Road from Station to Station: First, what by Lanes, or Roads you meet with in your Way, whether they be to the right Hand or to the left, and to what Places they go, and how they incline, whether forwards or backwards, or whether they be at right Angles with the Road you are measuring, and note it down in the Field-book with two Lines thus = on the right or left Side of the Station-line; that is, if the Road or Lane be on the right Hand, then place it on the right Hand; but if the Road be on the left Hand, then place it on the left: If the Road doth incline forwards, then make it on either Side of the Lane or Road thus $\angle$: If the Road or Lane incline backwards, then mark it thus ∇ : If it be at right Angles with the Road you measure, then mark it down thus $\perp$: If another Road crosses that you are upon, note it thus $\neq$: Likewise set down at what Distance from your Stations the Lanes or Roads do turn out from the Road you measure, viz. at so many Furlongs, &c. a Road to the Right or Left to such a Place.

Likewise, when you pass over any Bridge, note it in the Field-Book, with the Distance from the last Station; as also the Name of the Water that runs under it, and from whence it hath its Rise, and where it doth empty it self:

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So must you do when you pass over any Ford or Rill.

Note down also, when you ascend an Hill, and when you come to the Top thereof, and when you descend the same, and come to the Bottom thereof.

When you pass through any Town or Village, note at how many Miles, Furlongs, and Poles you enter the same; and at how many Miles, &c. you leave it, and whether the Houses be close, or scattering, or on the Right or Left Side of the Road, or on both Sides thereof; also write down the right Name thereof; and if a Market-Town, take Notice on what Day the Fairs or Market is kept; and by what Officers the Town is governed.

Note down also the Mills that are on the Road, whether Water-mills, or Wind-mills, and the Distance from your last Station. If there be any lone Churches on the Road, note them down by their Names, and whether they be Towers or Spires, with their Distance from your last Station.

In your measuring along the Road, if you see any Churches, Mansion-Houses, Beacons, Wind-mills, Towns, Villages, or any other Thing remarkable, you must take a Bearing to each, noting down in your Field-Book, the Name of the Place, and how it does bear, and at what Distance from your last Station you took this Bearing.

Then in your measuring forwards, at as great a Distance as you can, take another Bearing to those Places you took last, provided you may but see them, and note the Name of the Places, and how they bear, and at what Distance from your last Station, as before.

Observing these Directions, proceed with your Work on the Road as far as you can go the first Day,

Day, entring the several Observations in as plain and fair a Manner as possible in the Field-Book, and then it may be convenient to protract that Day's Observations, before you go any further.

Therefore, on the Paper or Parchment, on which you draw the foul Draught, let there be ruled Meridian-Lines all over, exactly parallel to one another; and chusing a proper Place in one of the Lines, to represent the first Station, draw an occult Line from thence, making such an Angle with the Meridian, as you observed the first Station-Line to do, when you directed the Telescope to the Man standing in the Middle of the Road.

When you have drawn the Station-Line in its true Position, set thereon the several Distances from the last Station very exactly, at which you made any Remarks, as you find 'em noted in the Field-Book; and make a small Prick at each, in the Station-Line: Then having made the Station-Line of its just Length, proceed to lay down the several Objects you observed on each Side the Road, in their true Situation; as suppose a Steeple that stands at a Distance from the Road, *viz.* a Mile or two; lay the Center of your Protractor on the Place at which you took the Bearing, thus, (at so many Poles, &c. Distance from such a Station, such a Steeple did bear from you $207^{\circ} 40'$,) therefore, against the Degrees of Bearing make a Mark, and draw a Line at Length.

Then at the second Place in the Station-Line, where you observed this same Steeple to bear from you, lay the Center of your Protractor, and against the Degrees of Bearing make a Mark, and likewise draw a Line at Length; and where this last Line of Bearing doth intersect the first
Line

Line of Bearing, there place the Steeple, with the Body of the Church to the East Side thereof.

All Wind-mills, eminent Houses, or other Remarks that are distant from the Road, you must protract in the same Manner as you did the Church, by the Bearings, and likewise write down the Name of each; and if you protract a Village that stands at a Distance from the Road, you must signify by Writing the same, that it is a Village; but that you may know Market-Towns from Villages, write the Name of the Market-Town in a different kind of Letter; and if you protract a Village that is in the Road, with Houses scattering, you must place your Houses scattering on the Right or Left Hand the Road, as you noted them in the Field-Book.

You must protract the Road all along with two Lines parallel one to the other. If your Road have Hedges on both Sides, then draw your Lines black; but if your Road be open Way, then draw it with prick'd Lines; also you may insert the Quality of the Ground, whether it be a Common, Moor, or arable Land.

If the Road pass through a Wood, then make little Trees on both Sides the Road, to signify the same so far as the Wood goes.

If the Road passes over an Hill, you must at the Beginning where the Hill doth ascend, shadow very deep, and as the Hill doth more and more ascend, you must shadow it lighter, till you come to the Top thereof: But if the Hill makes an Angle of above 5 or 6 Degrees, or thereabouts, and the Height be above a Furlong, you must find the horizontal Line of that Hill, and protract that, otherwise a great Error may ensue.

If there be a Village or Town on the Side of the Hill, you must shadow it likewise, so that the Houses may be seen. If the Remarks that
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are at a Distance from the Road stand on an Hill, make an Hill to represent the same.

If your Road pass by or through a Park, Forest or Chase, write down on your Road protracted, where you did enter the same, and where you did leave it, writing the Name thereof among the Trees.

If your Road pass over a Ford, draw the River quite cross the Road, to signify there is no Bridge, and write the Name of the Ford; but if there be a Bridge, then draw the River on both Sides the Road, 'till it touch the Parallel Lines; and write the Name both of the Bridge and of the River; likewise write on that Side of the Road that the Stream runs from you, and at what Place the River doth empty it self; and on the other Side of the Road write from whence the Water or River hath its Rise, if you can learn that of the Inhabitants.

All Rills you may signify, by drawing a Line cross the Road; and Brooks may be signify'd by drawing Two Lines cross the Road, and Rivers by more Lines, together with the Names; for all Rivers have Names, but Rills and Brooks have none.

It will likewise be necessary, that you take Notice of the Quality of the Way, whether it be stony or clayey or boggy, and write it down on the Road that you have protracted: And by this Means you will have your Road mighty full of Remarks, and it will shew very delightful.

S E C T. II.

*Containing general Directions for making the
Plott of a River or Brook, by the before-
mention'd Instruments.*

FIRST, when you come to the Mouth of the River, cause a Man to go and stand at the next Bend thereof; then plant your Theodolite at the Mouth of the River, letting your Needle hang directly over the Meridian-Line in the Box; there fix the Instrument fast, and direct your Telescope to the Man that stands at the next Bending of the River, and note down the Angle in your Field-Book, as you did in the Road.

Then cause the Man that drives the Wheel, to measure between your first Station, and the Man at the next Bending; and note that down also in your Field-Book, under Miles, Furlongs and Poles.

Then bring your Instrument to the Man at the first Bending of the River, and cause that Man to go forwards till he finds another Bending, there let him stand; and placing your Instrument where the Man last stood, let your Needle (as before) hang directly over the Meridian-Line, and there make your Instrument fast; and direct the Telescope to the Man that stands at the next Bending of the River, and note down the Angle in your Field-Book, as you did in the former: And thus must you proceed all along the River, to the Head thereof.

In order to take the Breadth of the River, it will be convenient to send some Body on Purpose cross the River, in a Boat, (unless a Bridge or Ferry be near,) and let him set up a Staff by
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the Brink of the River, on the further Side, to which Staff take a Bearing, from the Place of your Standing, which call the first Station; also let another Staff be set up on the same Side where you stand, and call that the second Station, to which take a Bearing also. Now measure in as strait a Line as possible, the nearest Distance between the 1st and 2^d Stations, and that Distance note in the Field-Book with the Bearings.

Plant the Theodolite at the second Station, and take a Bearing to the same Mark on the further Side of the River, and note that Bearing also in the Field-Book.

When you protract these Observations, lay the Center of the Protractor to $\odot_1$, and turn it about till the Diameter be parallel to the Meridians on the Paper, then against the Degrees of Bearing from $\odot_1$, to the Mark on the further Side of the River; and also to $\odot_2$, close to the Limb of the Protractor make 2 Marks, through which, from $\odot_1$, draw 2 Lines at Length.

Set off the Distance between the 2 Stations on the 2^d Line, and mark it $\odot_2$, to which Mark lay the Protractor as before, and against the Degrees of Bearing observed at this 2^d $\odot$; to the Mark on the further Side of the River make a Mark, through which draw a Line at Length; then will this Line intersect the first Line drawn at your first Station, so shall the Point of Intersection shew the Breadth of the River.

In the same Manner, are the Distance of the Churches, &c. from your Stations on the Road, determined; and in chusing the Distance of these Stations, 'tis very necessary to observe the Rule laid down at the Conclusion of Chap. I.

If there be a Ferry over the River, you must draw the River to its true Breadth, and make a prick'd Line cross the River, to represent the

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Passage

Passage of the Ferry-Boat; and note on the Side of the River the Name of the Ferry.

In measuring on by the River, observe what Bridges you pass by, and at what Distance from your last Station; also whether they be of Wood or Stone, and by what Name they are called; also take Notice of all Corn-Mills, Paper-Mills, &c. and note them in the Field-Book, in the Column of Remarks, with their Distance from the Mouth of the River, and your last Station.

Likewise take Notice of all the Sluices (if there be never so many) that are on the River, and of all the Locks and Flood-gates as you pass along, with their Names, if they have any; also if there be any cut Rivers from the River that you are measuring, note where it goes out of the River, and where it comes in again, and for what End it was so cut: Also where any Brook or River enters into that you are measuring, note down the Place, and the Name of the River that comes in; and also take an Account of those Places of the River that are fordable, and note them down in your Field-Book: And in all these Cases, express the Distance of each Remark from your last Station, as also their Distance from the Mouth of the River.

You must also note in your Field-Book all the Towns this River doth run through, or by, with the Towns Names, and the Distance from your last Station and the Mouth of the River.

You must also take an Account of all the Churches that are on each Side the River within your View, by taking a Bearing to them at two several Places, as you did on the Road; and note them down in your Field-Book, with the Distance of the Place from your last Station, where you took the Bearing, to the Steeple both Times; by this Means you will come to know how far each

each Church is distant from the River: The same you must do by all the Wind-mills, great Houses, &c. noting their Names, and Places of Situation, in the Column of Remarks in the Field-Book.

When you have thus measured your main River, begin to measure the several Branches thereof; for there are but few Rivers but have smaller Rivers running into them, and all those small Rivers ought to be done with the like Exactness with the great ones.

Note, All Rivers that are navigable, every Bending of them must be taken exactly; but for other small Creeks there is no great Need; for you will find such small Brooks to have a Bend at every two or three Poles, nay sometimes less, therefore they are to be taken thus:

Take your Sight as far as you can conveniently, till you find the Brook to have a considerable Bending; and if your Scale will permit, you may take Offsets to represent the small Turnings and Windings thereof, as in *Fig. 22*: But in measuring a small Brook, if your Scale is to be a Mile or two in an Inch, then these small Turnings and Windings can't be described in the Map.

The Manner of protracting these Observations, is the same with the Roads, except the Offsets from the Station-Line to the Brink of the River, and its Breadth, which are particularly to be regarded.

S E C T. III.

General Directions for making a Map of a County, &c.

First, from the County-Town, or other Market-Town, where you began your Work, lay down the principal Roads throughout the County, protracting them truly, as you observed them in your Survey, inserting the Towns, Villages, great Houses, Cross-Ways, &c. according to their true Situation, taken at Two Stations, as you went on the Road; so will you (if Care be taken) have the true horizontal Distance of all those Places within Sight of the Roads, from the Road itself, or from one another.

Secondly, Lay down the chief River that runs through the County, so will you have the Situation of several more Towns, and other Remarks, as observed in your Survey of that River; and when the main Rivers are done, all the Branches must be protracted with the like Exactness; for the main Rivers and Branches being exactly done, will be a great Ornament to a County Map.

Thirdly, If the County borders upon the Sea, first protract the Sea-Coast exactly, and then take a Survey of and plott all Rocks, Sands, or other Obstacles that lie at the Entrance of any River, Harbour, Bay or Road upon the Coast of that County, by going out in a Boat to such Sands or Rocks that make the Entrance difficult; and at every considerable Bend of the Sands, take with a Sea-Compass, the Bearing thereof, to Two known Marks upon the Shore: And having so gone round all the Sands and Rocks, you may, upon the Plott before taken of the Coast, draw
Lines,

Se^{ct}. 3. *The Practical Surveyor.* 149

Lines, which shall intersect each other at every considerable Point of the Sands ; whereby you may give good Directions either for the laying of Buoys, or making Marks upon the Shore, for the Direction of Shipping ; and the best Time to do this, is at low Water, in Spring Tides.

Fourthly, Having truly protracted the principal Roads, Rivers, &c. with the several Remarks observed from thence, you'll find most of the remarkable Places in the County laid down : But in Order to compleat the Work, look upon some old Map of the County, and contrive 3 or 4 Market-Towns, or other Towns, to measure through, that you have not yet laid down, and from thence to other Towns or Villages ; and so do, till you have measured most or all the Roads that lead from Market-Town to Market-Town, taking all the Remarks you can, as you go along ; and if you find any thing remarkable in the old Map, that you have not yet taken Notice of, you may go and survey it. And thus, by Degrees, you may so finish a County, that you need not so much as leave out one Gentleman's House ; for scarce will any thing remarkable escape coming into your View, either from the Roads, Rivers, or Sea-Coast.

Fifthly, When you are in a Town, you may place your Instrument, if you can, upon the Steeple, and from thence take the horizontal Angles to others, by having the horizontal Distance of those 2, from which you take your Angles given ; but observe, all Churches are to be laid down according to their horizontal Distance one from the other : Therefore, if the Road between them be over Hills of a considerable Height, the Hypothenusal Lines on the Road must be reduced to Horizontal.

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Sixthly,

Sixthly, All Parks and Forests must be truly laid down in the Map, as to their true Bounds and Situation ; and all remarkable Lakes of Water : You are likewise to describe the Quality of the County, whether it be hilly or woody, placing the Hills and Woods in their true Places.

Lastly, Take the true Latitude of the Place, in Three or Four Places of the County ; which put down on the Edge of your Map accordingly.

S E C T. IV.

General Directions for taking the Ground-plot of a City or other Town.

THE Performance of this Work is very laborious, and you must be careful to keep the Field-book in a plain and regular Manner, otherwise the Multitude of Observations and Offsets will be apt to breed Confusion ; but if Care be taken therein you'll find the Work not very hard to be done : One that understands the fourth Chapter will make no Difficulty of this Section, for the several Streets, Lanes, &c. in a City are survey'd and protracted in the same Manner as the Lane *Fig. 21.* The several Offsets to the Houses, Churches, &c. all along the Sides of the Street being taken from the main Station-line, running through the middle thereof, in such Sort as the Offsets are taken from the Station-line to the Hedges, Gates, &c. on the Sides of the Lane.

The Instruments for this Purpose are, 1. the Theodolite as before described, to measure the several Angles made by your Station-lines, as they incline out of one Street into another, and in this Case work with the Limb only, but never trust

to

to the Needle, for (besides the Danger of its being attracted) you will find it necessary to lay down every Line by some other, given in Position in the Plott it self, rather than by the Bearings from the Meridian.

2. The Chain; and because the Ground-plott of the Houses, Pavements, &c. are generally laid out by Foot Measure; therefore let every Link thereof be a Foot long, and Fifty of these Links will make the Chain of a sufficient Length, distinguished at every Ten Links, by Marks, as *Gunter's Chain* is: But if the Content of any Part of the Plott be desired in Acres, you may reduce the Feet in any Line, to Links; and for this Purpose the Table in Chap. I. will be a ready Assistant.

3. The Offsett-Staff, divided also into Feet, 5 of which may make it of a convenient Length, because you will have Occasion to measure many Passages, Alleys, &c. that are not wider; also at one End of the Staff, you may have a Piece of about 3 Foot joined, like the Squares of a Drawing-Board; and this will be a Direction to measure the Offsets from the Chain, at Right-Angles.

4. The Scale, (or rather a Pair of Beam-Compasses) according to the Bigness of the Plott, the Protractor, the Drawing-Pen, &c.

First, in one of the principal Sheets, as at Θ 1, in the Lane, *Fig. 22*, set up a Station-Staff, and send another forwards in the Street as far as you can see. Then lay the Chain on the Ground exactly in the same Direction with the Two Stations, and with the Offset-Staff both to the right and left at Right-Angles from the Chain; measure the Offsets as in the Lane; taking Notice at how many Links from the last Station each is laid off; and when any of those Offsets reach any

remarkable House, &c. or the Corner of a Street, Alley, or Court, enter such a Remark against the respective Offset, in one of the Outside Columns of the Field-Book: And in this Manner proceed to the second Station.

Set up the Theodolite at the second Station, and bring the Index to 360, on the Limb, turning the whole Instrument about till you see thro' the Telescope the Staff at $\odot$ 1; there fix the Instrument, and then turn about the Index, directing the Telescope to another Staff sent forwards in the Street, to the further End thereof, if you can see so far; and note in the Field-Book the Angle which the Index cuts on the Limb, with the utmost Exactness: Then proceed with the Chain towards the next Station, as before.

Having in this Manner gone through several of the principal, high Streets, that lead through one Part of the Town, it will be convenient, as you pass along, as often as you come against any cross Street, to take a Sight down it; and note the Place or Mark to which the Telescope is directed; and also at how many Links Distance from the last Station the Instrument is planted, when you thus look into a cross Street; and note both these Places in your Field-Book, or Eye-Draught, with this Mark $\odot$; so that you may be sure to find the Place exactly, when you begin to take your cross Sheets.

It will be convenient, not only to enter your Observations in the Field-Book, but also to form a Sketch or Eye-Draught of the Work, as you go along, making Lines to imitate the same; and draw the cross Streets, Alleys, &c. thereon, in such Manner (as near as you can guess) as you see those cross Streets to bear from the Place of your Standing in the high Streets; and write the Name of each Street between the Lines representing

senting the same; and this will be useful when you come to protract.

Note, Before you begin your Work, it will be necessary to walk about the Town, and chuse 4 or 5 principal Streets that lead out of one into another, enclosing between them several By-Lanes, Alleys, &c. And contrive your first Station in such Manner, that when you come round these 4 or 5 Streets, the last Station-Line may close exactly on the first Station-Point; and observe, that the fewer Angles you make in going round these Streets before you close, the better.

This is no more than Surveying a Field; the main Difficulty will be to find your Stations, when you come to survey the cross Streets, By-Lanes, Thorougfares, &c. between the eminent Streets that you first went round; but you may help your self herein, if you lay one End of the Chain at some Door, or other remarkable Place on the Right Side of the Street, and draw it in a strait Line through the Station-Point, to some other Remark on the other Side of the Street, taking Notice at how many Links from the Right, the Chain cut the Station: You may also much help yourself herein by your Eye-Draught.

When the Station-Line leads you into a Square, you may plant the Theodolite in the Middle thereof, and from that one Station direct the Telescope to the Corners, (very often there are but four, and the Sides all strait) and measure the Distances from that Station to the Corners, as in Chap I. Sect. 3. But if you would take Notice of particular Houses therein, or if the Sides are very irregular, then go round it; but Lanes and Alleys are laid down by Offsets only, from the Station-Line through the Middle.

Having

Having thus finished one Part of the Town or City, you may proceed to another, till the whole be finished ; but this is a Work that will take up a great deal of Time.

The Manner of Protracting this Work, is the same as in the preceding Chapters, therefore particular Directions are needless ; but 'tis best to protract so much as you survey in one Day, before you proceed with more ; and for this Purpose, a Skin of fine, soft Parchment is better than Paper, unless the Paper be very fine, and pasted on Cloth or Canvas. The Ground-Plotts of Churches, must be very exactly taken, and laid down in the same Manner on the Draught, and shadowed very deep ; the same of Houses.

Also if you use a Protractor that will lay down Minutes, as described in Chap. II. your Work will be more likely to close ; for you cannot be too curious in observing and laying down the Angles, especially those in the principal Streets.

F I N I S.



APPEN-



APPENDIX

TO THE

Practical SURVEYOR.

CHAP. I.

Of LEVELLING.

SECT. I.



THE Instrument most approved for this Purpose, (a Figure whereof you have in the Beginning of this Book) consists,

1. Of a Brass Telescope of a convenient Length (the longer the Exacter, provided the Parts of the Instrument that support it, be made proportionably strong:) Within this Telescope is fixed an horizontal Hair, and a small Micrometer, whereby Distances may be determined at one Station near enough for the Business of Levelling: Upon this Telescope is fixed, with two small Screws, the Spirit Tube, and Bubble therein, which Bubble rest exactly in the Middle of the Tube, when the Telescope is set truly level.

2. Under the Telescope, is a double Spring, with 2 Screws, by which the Bubble is brought exactly to a Mark in the Middle of the Tube; to which Spring is fixed a Conical Ferril, which is a Direction for the Telescope to move horizontally at Pleasure. There is also a three-legged Staff, a Ball Socket, and 4 Screws, to adjust the horizontal

horizontal Motion the same with that belonging to the Theodolite, before described.

Provide 2 Station-Staves, each 10 Foot long, that may slide one by the Side of the other to 5 Foot, for easier Carriage; let them be divided into 1000 equal Parts, and numbred at every 10th Division, 10, 20, 30, 40, &c. to 100, and from 100, 110, 120, &c. to 200, and so on till you come to 1000; but every Centessimal Division, as 100, 200, 300, to 1000, ought to be expressed in large Figures, that the Divisions may be more easily counted; and you may have another Piece 5 Foot long, divided also into 500 Parts, to be added to the former, when there shall be Occasion.

Upon these Staves are Two Vanes, made to slide up and down, which will also stand against any Division on the Staff, by the Help of Springs. These Vanes are best, made 30 Parts wide, and 90 Parts long; let the Faces of them be divided into 3 equal Spaces, by 2 Lines drawn lengthways; let the 2 extreme Spaces be painted white, and let the middle Space be divided also into 3 smaller equal Spaces, and let that in the Middle be painted white, the other 2 black, which will render them fit for all Distances.

Being thus provided with a good Instrument, Two Station-Staves, a Chain, and Two Assistants, you may proceed to your Work; but first it will be necessary to make a Trial whether or no your Instrument be well adjusted.

S E C T. II.

How to adjust the Instrument.

CHuse some Field or Meadow, that is nearly level, and set down the Instrument about the Middle thereof, and make an Hole in the Ground, under the Center of the Instrument; from

from which, measure out in a Right-Line, some convenient Length, as 20 Chains, and there leave one of your Assistants with his Station-Staff; then return to the Instrument, and measure out the same Number of Chains, *viz.* 20, the other Way, by the Direction of the Instrument, and last Station-Staff, as near in a Right-Line as you can guess, and there leave your other Assistant with his Station-Staff; so will the Instrument and Two Station-Staves be in the same Line.

Then return to the Instrument, and set it horizontal, which is presently done by the Ball and Socket, and turn the Telescope about on its horizontal Motion, to your first Assistant, and move the Telescope by the Two Screws in the double Spring, till the Bubble rests exactly in the Middle of the Spirit Tube; then observe where the Hair in the Telescope cuts the Staff, and direct your Assistant to move the Vane up or down, till the Hair cuts the Middle thereof, so that you may see as much of the Vane above the Hair as below it, and there give him a Sign to fix it; then direct the Telescope towards your second Assistant, and proceed in the same Manner; so are the Vanes on each Staff equidistant from the Center of the Earth.

Remove the Instrument to that Assistant which is nearest the Sun, if it shines, that you may have the Advantage of its Rays upon the other Assistant's Vane, and there set down the Instrument as near the Staff as you can; then having set the Instrument horizontal, so that the Bubble rests in the Middle of the Tube; observe what Division on the Staff is then cut by the Hair in the Telescope, above or below the Middle of the Vane, for so many Divisions must the other Assistant's Vane be raised or depressed, which direct him to do accordingly.

But

But because the Instrument is 40 Chains distant from the Station-Staff, you must make an Allowance for the Earth's Curvature, which by the following Table you will find to be $16\frac{6}{10}$ Parts, therefore let the Vane on the Staff be raised $16\frac{6}{10}$ Parts.

A TABLE of the Earth's Curvature, calculated to the Thousandth Part of a Foot, at the End of every Chain, from 1 Chain to 40.

<i>Chains</i>	<i>Dec. Foot</i>	<i>Chains</i>	<i>Dec. Foot</i>	<i>Chains</i>	<i>D. Foot.</i>	<i>Chains</i>	<i>D. Foot.</i>
1	000	11	013	21	046	31	099
2	00	12	015	22	050	32	106
3	001	13	017	23	055	33	113
4	002	14	020	24	060	34	120
5	003	15	023	25	065	35	127
6	004	16	026	26	070	36	134
7	005	17	030	27	075	37	141
8	007	18	033	28	081	38	149
9	008	19	037	29	087	39	157
10	010	20	041	30	093	40	166

Now direct the Telescope to the Vane thus raised, and if the Hair cuts the Middle thereof, while the Bubble rests in the Middle of the Tube, the Instrument is right; but if not, you must raise or depress the Telescope by the Screws in the double Spring, till the Hair cuts the Middle of the Vane, and then by the Help of the Screws that fix'd the Tube to the Telescope, move the Bubble till it rests in the Middle of the Tube: So is the Level adjusted.

SECT.

S E C T. III.

Rules to be observed in Levelling, in Order to find the different Height of any two Places; being useful for conveying Water, cutting Sluices, making Soughs, &c.

SUPPOSE it was required to know whether Water may be conveyed in Pipes or Trenches, from a Spring Head to any determined Place.

1. At the Head of the Spring set up one of your Station-Staves as nearly perpendicular as you can, and leave with one (whom you may call your first Assistant) proper Directions for Raising or Depressing the Vane on his Staff, according to certain Signs which you (standing at your Instrument) shall give him: Also let him be provided with Pen, Ink and Paper, to note down very carefully the Division on the Staff which the Vane shall cut, when you make a Sign that it stands in its right Position.

2. Carry your Instrument towards the determined Place you are going to, as far as you can see, so that through the Telescope you may but see any Part of the Staff left behind, when the Instrument is set horizontal; and from that Place send your second Assistant forwards with his Station-Staff with the same Instructions as you gave your first Assistant.

3. Set the Instrument horizontal, by the Help of the Ball, and Socket and 4 Screws; and direct the Telescope to your first Assistant's Staff, and then by the Help of the Spring-screws bring the Bubble exactly to the Middle of the Tube, and when it rests there, give a Sign for your Assistant

Assistant to note the Parts of the Staff where the Vane rests.

4. Turn about the Telescope to your second Assistant's Staff, and by the Spring-screws, as before, set the Bubble exact: Then direct your second Assistant to move the Vane higher or lower till you see the Hair in the Telescope cut the Middle of the Vane, (but in long Distances the Hair will almost cover the Vane; however, let it be set in such Manner that as much may be above the Hair as below it, as near as you can guess,) and then give him a Sign to note the Division on the Staff; and always let your Assistants note the Division cut by the upper Edge of the Vane.

5. Let your first Assistant bring his Station-Staff from the Spring Head, and give it to the second Assistant, and let your second Assistant carry it forwards towards the determined Place you are going to, and at a convenient Place erect it perpendicular, whilst your first Assistant tarries at the Staff where your second Assistant stood before.

6. Place your Instrument between your Two Assistants, somewhere about the Middle if you can, and first direct the Telescope to your first Assistant's Staff, and when the Telescope is levelled to one of the Divisions on the Staff, let him note that Division in an orderly Manner under the first Observation; and let your second Assistant do the same: And in this Manner proceed over Hill and Dale, as strait forwards as the Way will permit, to the appointed Place, (by only repeating these Directions, tho' it be 20 Miles distant from the Spring Head; but in your whole Passage let this constant Law be observed, otherwise great Errors will ensue, (*viz.*) That your first Assistant must at every Station stand between

the

the Spring-head and your Instrument, and your second Assistant must always stand between the Instrument and the appointed Place to which the Water is to be convey'd.

Being come to the appointed Place, let both your Assistants give in their Notes, which ought to stand in Manner and Form following.

<i>First Assistant's Notes.</i>		<i>Second Assistant's Notes</i>	
<i>Stations.</i>	<i>Parts.</i>	<i>Stations.</i>	<i>Parts.</i>
⊙ 1	1019	⊙ 1	330
⊙ 2	512	⊙ 2	540
⊙ 3	737	⊙ 3	1337
⊙ 4	40	⊙ 4	742
⊙ 5	1495	⊙ 5	30
⊙ 6	1475	⊙ 6	32
⊙ 7	1430	⊙ 7	30
⊙ 8	1149	⊙ 8	227
<i>Sum.</i>	7857	<i>Sum.</i>	3268

These Notes were collected from Observations made with such an Instrument, as before described, at several Stations between the Ground at the North-gate of *Hanover-Square*, and the Surface of the square Pond by the *New-River Head*, near *Islington*. The first Assistant's Notes, when added together, amount to 7857; the second Assistant's 3268, the Difference 45, 89 Parts; that is almost 46 Foot; and so much is the Pond higher than the Ground of that Part of the Square where the first Station-staff was planted.

The following Observations were repeated in the Afternoon of the same Day, at quite different Stations; from the Pond before-mention'd, to the said North-gate of *Hanover-Square*; and then

M

the

the two Assistants Notes stood in the following Manner.

<i>First Assistant's Notes</i>		<i>Second Assistant's Notes</i>	
<i>Stations.</i>	<i>Parts.</i>	<i>Stations.</i>	<i>Parts.</i>
⊙ 1	290	⊙ 1	1278
⊙ 2	36	⊙ 2	1515
⊙ 3	77	⊙ 3	1395
⊙ 4	68	⊙ 4	1500
⊙ 5	58	⊙ 5	74
⊙ 6	1243	⊙ 6	38
⊙ 7	998	⊙ 7	468
⊙ 8	437	⊙ 8	774
⊙ 9	306	⊙ 9	1066
<i>Sum.</i>	3512	<i>Sum.</i>	8108

These Notes as observed in the Afternoon, being added together, and the lesser subtracted out of the greater, the Difference is 45,95 Parts, which very nearly agrees with the former Observations; being but $\frac{4}{100}$ of a Foot Difference, which is inconsiderable.

Note, If from the first Assistant's Staff you measure any Number of Chains towards the Place you are going to, suppose 10, and there set down the Instrument, and then measure 10 Chains forwarder and there place the other Station-staff, you will have no Occasion to make any Allowance for the Curvature of the Earth, because the Instrument being planted in the Middle of the Distance between the Station-staves, the Errors mutually destroy each other.

But this measuring of the Distances with the Chain, or otherwise, is very tedious, and indeed impracticable in many Cases, unless you make a Multitude of Stations: So if the Way between the two determined Places, whose different

rent

rent Height you would know, lies over Hills and Dales, as *Fig. 32.* you must in that Case make four or five Stations (otherwise you will not be able to see any Part of the Staff, when the Instrument is set horizontal,) which might as well be done at one, (as in the foregoing Observations,) in the following Manner.

S E C T. IV.

How to make Allowance for the Curvature of the Earth; when the Station-staves are planted at unequal Distances from the Instrument.

SUPPOSE the Instrument was planted on the Eminence between the two Valleys *a*, and *b*, and the first Assistant with his Station-staff, standing at *c*, and the second at *d*, and it is required to know the different Height of the Hills *c*, and *d*.

First set the Instrument horizontal; and then direct the Telescope to the first Assistant's Staff at *c*, and by the Spring-screws set the Bubble exact, observing where the Hair cuts the Staff, and by Signs cause him to move the Vane higher or lower till the Hair cuts the Middle thereof; and then give him a Sign to note the Division cut by the upper Edge of the Vane, which suppose 104 Parts from the Ground, and by the Micro-meter in the Telescope, I find the Distance from the Instrument to the Staff at *c*, to be about 10 Chains.

Then I direct the Telescope to *d*, and proceed in the same Manner as before, and find that the Hair cuts 849 Parts from the Ground; and

by the Micrometer the Distance to d , is determined to be about 35 Chains.

Next I look into the Table of Curvature and find against 10 Chain, 1 Part to be deducted for the Curvature of the Earth at that Distance; so will the first Assistant's Note be made 103 Parts.

Also against 35 Chains I find $121\frac{2}{5}$, which deducted out of 849, there remains $836\frac{3}{5}$ Parts which must be noted by the second Assistant.

Now if 103, as noted by the first Assistant, be subtracted from $836\frac{3}{5}$, as noted by the second, the Remainder will be $733\frac{3}{5}$; and so much the Hill c , is higher than the Hill d : But if you have not the Table of Curvature at Hand, then you may find the Allowance that is to be made at any Distance, by this Rule:

Multiply the Square of the Distance in Chains by 31, and divide the Product by 300000.

In this Manner making Allowance for the Curvature of the Earth, you may send a Station-staff forwards half a Mile, or farther from the Instrument; and take a Sight over several Valleys at once, the horizontal Distance in this Case being only regardable.

Note, When Water is to be brought to any appointed Place; there must be an Allowance of $4\frac{1}{2}$ Inches for every Mile, more than the strait Level, for the Current of the Water; but if the Spring-head be much higher than the appointed Place, so that the Water will have too violent a Current, the Pipes may be laid one up and another down; and instead of being laid in a strait Line, the Water be brought in a crooked or winding Way.



CHAP. II.

*Shewing the Use of the Theodolite,
in Drawing Buildings, &c. in
Perspective.*

SECT. I.



WHEN a Building is to be drawn upon a Perspective Plane (or Picture,) the Representation of the several Objects ought to be delineated thereon according to their Dimensions and different Situations, in such Manner that the said Representations may produce the same Effects on our Eyes as the Objects whereof they are the Pictures.

But without Mathematical Rules this Representation cannot well be found; for when Objects are drawn by only Viewing or Looking at them, their true Representations will often be miss'd; whereas by the following Method they may always be obtained.

For all Objects appear such as the visual Angle under which they are seen; which Angle is taken at the Eye, where the Lines meet that do comprise the Object; that is to say, an Object seen in a great Angle, will appear great; and another seen in a little Angle, will appear little; which is the principal Thing to be observed in Perspective.

So the Windows 6, 7, 8, *Fig. 32*, must be drawn on the Perspective Plane of different Dimensions (altho' on the Building one of 'em is really as big as the other) according to the Angle which the Rays from their Extremities make with the Eye at *z*.

Objects of equal Bigness appear greater or less, according to their Distance from the Beholder's Eye; so the Windows 6 and 8, are really one as big as another on the Geometrical Plane; but the Window 6, at the End of the Building being nearer the Eye at *z*, than the Window 8 on the Front, it must be made so much larger on the Perspective Plane, as the Window 6 is to that marked with 8.

Therefore, if the Angles, under which Objects appear, be given, those Objects may be drawn on the Perspective Plane (or Paper) according to their Dimensions and different Situations, in the same Form as they appear to the Beholder at any Distance.

The Figures on the Geometrical Plane (or Building) are compos'd either of strait Lines, or Curves: Now to find the Representation of a strait Line, its Extremes need only be sought: And to find the Appearance of a Curve, we need only to find the Place of several Points therein. And hence it follows, that the whole Business of Perspective consists in finding only the Place of a Point.

But these Points can't be determined, unless by the Intersection of Right Lines. And the Reason of these Sections is, That one Line can determine nothing: Therefore it is necessary, that there be Two of them, which divide themselves, (forming an Angle) for to have the Place of a Point, as will be seen in the following Example.

For

For having noted the Observations made by the Theodolite, the Plan of any Building may be drawn in Perspective, without measuring so much as one Line; or coming nearer the Building than where the Instrument is planted.

S E C T. II.

Let Fig. 33. represent the Building as viewed from Z, being the Place from which the Prospect is desired to be taken.

THE Instrument being planted at *z*, and the Staves made to stand firm on the Ground, I set the Instrument exactly level; and with the Index at 360, and the Quadrant at 0 Degrees, direct the Telescope to some Part of the Building, as to *o*, by turning about the whole Instrument, and there screw it fast, that it stir not out of this Position, till the several Observations be finished.

The Instrument being set level, the Index, when turned round on the Limb, carries the Telescope in a Line Parallel to the Horizon, as *x, y*: And the Quadrant elevated or depressed, moves always in a Circle vertical thereto, as *w, z*.

Now take the Pin out of the Quadrant, and with one Hand move the Index on the Limb, and with the other elevate or depress the Telescope as there shall be Occasion, till you see the cross Hairs therein cut any Point on the Building; and then note down on a Piece of Paper, the Degrees and Minutes which the Index cuts on the Limb in one Column, and call those the horizontal Angles: Likewise note the Degrees and Minutes cut by the Quadrant in another Column, and call those the vertical Angles.

So the Telescope being directed to the Point *a*, the Index then cuts $7^{\circ}, 25'$, and the Quadrant $19^{\circ}, 30'$; and those Observations when protracted, will give the Point *a*.

Likewise I make Observation of the Point *b*; and then depress the Telescope to the Bottom of the Building at *c*, and the Index then cuts the same Angle on the Limb as at *b*, and the Quadrant $8^{\circ}, 30'$: But this Angle of Depression must be marked with $\wedge$, or some such Mark to distinguish it from the Angles of Elevation, that in Protracting that Point, it may be known to be under the Horizon, or the Line *x, y*.

When the Instrument is planted at a considerable Distance from the Building, the Ground there may be higher or lower than any Part of the Building: And then all the Points will be above or under the Horizon; and in such Case there will be no Occasion for this Distinction.

In the same Manner I make Observation of so many Points on the Right Side of the House as is convenient; but when the Telescope is directed to the Point *m*, on the Left Side, the Index cuts $340^{\circ}, 40'$.

Now this Number $340^{\circ}, 40'$, must not be noted for the horizontal Angle, but its Complement to 360 (*viz.*) $19^{\circ}, 20'$, by subtracting $340^{\circ}, 40'$, out of 360; but if the Degrees be numbred by small Figures from 360, the contrary Way, as 10, 20, 30, &c. to 60, or further, as may conveniently be done, the Numbers will encrease from 360, both to the Right and Left; and then the Index will always cut the Number denoting the horizontal Angle, in the same Manner as the Quadrant.

Having observed the Point *m*, the Index remaining at the same Angle on the Limb, I depress the Telescope to the Points 4, 3, 2, 1, and
note

note the Degrees, &c. cut by the Quadrant; which when protracted, will give the Breadth of the Facies and their Distance one from another.

Next I observe the Points of the Window *e, i, u*, in the Left Wing of the Building; and because these Remarks are on the Left Side of the Building, therefore I note them by such Names as I call the several Points I look at, (instead of the Letters, *a, b*, &c. on the Left Side of the Column of Observations, (*viz.*) contrary to that Part of the Limb where the Index cuts, (which remember;) for when the Index is turned from 360, on the Limb towards the Right Hand, the Telescope moves towards the Left: And these Remarks thus noted, must be protracted on the Left Side of the Vertical Line *w, z*, *Fig. 33.*

In making these Observations, 1. Set the Instrument level in that Place from which the Prospect is desired to be made; and with the Index at 360, direct the Telescope to some remarkable Place about the Middle of the Building, and there fix the Instrument.

2. The Remarks on the Right Side of the Building, enter in the Column of Observations on the right Hand; & *è contra.*

3. If there be Angles both of Elevation and Depression, mark the Angles of Depression with $\wedge$.

The Observations of most of the Points, that need to be taken of *Fig. 32*, in order to protract or draw the same in Perspective, are inserted in the following Table: And observe, that if the Building be regular, there will need but few Points to be given; for, where you have the Height and Breadth of one Window given, with its Distance from the next, the whole Row may thereby be drawn, being all of the same Dimensions; but
Objects

Objects more irregular must be drawn by observing so many Points therein, as shall be necessary: But Practice in this Case is the best Guide.

S E C T. III.

The Manner of Protracting these Observations in Order to find the Points of the Building, Fig. 33.

Horizon. Angles		Vertical Angles	
7° : 25'	19° : 30'	a	}
11 : 30	16 : 30	b	
11 : 30	8 : 30	c	
19 : 20	26 : 50	d	
19 : 20	13 : 30	e	}
38 : 00	26 : 50	f	
38 : 00	13 : 30	g	}
4	19 : 20	26 : 50	
		25 : 30	}
3		18 : 40	
2		9 : 35	
1		1 : 00	
i	18 : 30	19 : 00	}
e	18 : 30	22 : 40	
u	16 : 50	17 : 50	

FIRST draw a right Line x, y , Fig. 33. for the Horizontal-line; and at right Angles therewith draw another Line w, z , which represents the Vertical-line.

Set off the Points of Distance from o , (*viz*) from that Point where x, y , and w, z , intersect one another: And according to what Big-
ness

ness you would have the Plan of the Building be, make the Distance bigger or less. If you would have the Draught large, make the Distance large: *Et à contra.* Therefore set one Foot of the Compass at o , and with the same Extent mark the Points of Distance x , y , z .

The Horizontal-angles must be drawn from the Point z , to the horizontal Line x , y ; and the vertical Angles from the Points x , or y , (according as the Remarks are noted on the right or left Side of the Columns) to the Vertical-line w , z .

The Index being at 360 , and the Quadrant at o , when the Cross-hairs in the Telescope cut the Point o , on the Building: Therefore the Point o , shall be the first Point of Sight on the Prospective-plan.

By the Table of Observations I find that the Index cuts $7^{\circ} 25'$ on the Limb; and the Quadrant $19^{\circ} 30'$, when the Telescope was directed to the Point a : Therefore lay the Center of the Protractor to z : And because the Letter a is noted on the right Side of the Columns, lay the Limb on the Right Side of the Line w , z , the Diameter coincident therewith; and against $7^{\circ} 25'$, make a Mark close by the Limb of the Protractor.

Lay the Edge of a strait Ruler to the Point of Distance z , and to that Point $7^{\circ} 25'$; and where the Edge cuts the Horizontal Line, make a Mark.

Lay the Center of the Protractor to the Point of Distance y , (because a is noted on the Right Side of the Columns) the Diameter coincident with the Line x , y ; and against $19^{\circ} 30'$, on the Limb, make a Mark.

Lay a strait Ruler to that Mark, and the Point of Distance y ; and where the Edge cuts the Vertical Line w , z , make a Mark at r .

Lastly, Lay a Parallel Ruler to the Horizontal Line x , y , and move it Parallel thereto, till the Edge

Edge cuts the Point r , in the Vertical Line; and with the Compass Point draw the obscure Line $r s$.

Then lay the Parallel Ruler to the Vertical-Line w, z , and move it Parallel thereto till the Edge cuts the Point t , in the horizontal Line x, y , and by the same Edge draw an obscure Line $t q$; so shall the Intersection of these Two Parallels determine the Place of the Point a , which was sought.

In the same Manner may the Point b , or any other Point be found: And then these Points joined with Right Lines, shall represent the Lines on the Building, and bear an exact Proportion thereto, according to the Rules of Perspective.

The Point c is found in the same Manner as a , only because the horizontal Angle is the same with the Point b , you have no more to do but continue a strait Line from b , through the Point x , in the Horizontal Line, Parallel to w, z ; and then lay the Center of the Protractor to y , with the Limb downwards; because c is marked with Λ (*i. e.*) under the Horizon; and draw the Vertical Angle $8^\circ, 30'$, to γ in the Vertical Line; so shall a Line drawn Parallel to x, y , from the Point γ , cut the obscure Line b, c , at c , the Point sought.

The Points b, k, l, m, n, p, q , on the Left Side of the Building, *Fig. 33*, have the same Angles with a, b, c, d, e, f, g , on the Right, and therefore protracted in the same Manner; except this Difference, that because the Points $b, k, l, \&c.$ are on the Left Side of the Building, therefore the same Points must be found on the Left Side of the Vertical Line w, z , and the Protractor laid to the Point of Distance x ; but the Horizontal Angles are all laid off from the same Point of Distance z .

Observe,

Observe, That in Protracting these Points, 'tis convenient, that the Numbers on the Semicircular Protractor should be made to encrease from the Diameter both Ways, that the Numbers may be counted thereon, both to the Right and Left: And then in Protracting any Point on a Building,

1. Draw the Horizontal Angle from the Point of Distance z , to the Horizontal Line x, y , as to t .
 2. Draw the Vertical Angle to the Vertical Line w, z , as to r . 3. Draw Lines Parallel to w, z , and x, y , through the Points t and r ; so shall the Intersection of the Two Parallels give the Point sought.

But these Points are found with much greater Expedition, if the Paper on which you draw the Plan of the Building, be fastened to a Drawing-Board, and the Angles laid down by the Sector in the following Manner:

For Example: Suppose the Point a , *Fig. 33*, was sought.

First, Draw Two Lines by the Side of the Tee, crossing one another at Right Angles, as x, y , and w, z , *Fig. 33*.

Take between the Points of the Compasses the Distance z, o , and let the Sector be opened to the same Extent, by setting one Foot of the Compasses at the End of the Tangent-Line, at 45° , on one Side of the Sector, and let the other fall at the other End of the Tangent-Line, at 45° , on the other Side of the Sector.

The Sector remaining at this Extent, set one Foot of the Compasses in the Tangent-Line on one Side of the Sector at $7^\circ, 25'$, the Horizontal Angle, as in the Table; and let the other fall at $7^\circ, 25'$, on the other Side; this Distance set from the Point of Sight o , in the Horizontal-Line x, y , to t .

In

In the same Manner take off from the Sector the vertical Angle $19^{\circ} 30'$ which set on the vertical Line w, z , from o to r .

Lastly, lay the Tee on the Drawing-board, parallel to w, z , so that the Edge cut through the Point t , and draw the Obscure-Line t, g .

Lay the Tee to the other Side of the Drawing-board parallel to x, y : And the Edge cutting through the Point r . Draw the Obscure-Line r, s , so shall the Intersection of these two Lines t, g , and r, s , give the Point a which was sought.

In the same Manner may any other Point be found in as little Time as it could be observed by the Theodolite; but if you have not a Drawing-board nor Parallel-ruler, you may put the Paper on the plain Table and by the Edge of the Index laid on the equal Divisions, draw the Parallels; but a Drawing-board is better.

Having found the Points m and k , both denoting the upper Part of the Facies, if you lay a Ruler to these two Points, and continue a strait Line till it cuts the Horizontal-line x, y , as at f , that shall be the accidental Point, (or, as the Draughts-Men sometimes call it, the vanishing Point,) which being found, you may from thence draw right Lines to any other Points on the Draught which were viewed obliquely from z ; (and therefore the Figures on that Part of the Building must be made inclined on the Draught,) and thereby find the Abridgment of all the Lines parallel to the Horizon on the Building or geometrical Plan; (which is supposed parallel to the perspective Plan or Picture)

So when you have protracted the vertical Angles of 4, 3, 2, 1, *Fig. 33.* and thereby found those Points. You may lay a Ruler to each of them, and the accidental Point f , and thereby draw

draw the Facies on the Wings of the Building according to their Breadth and Distance from one another on the perspective Plane or Draught.

In like Manner having found the Points e , i , and u of the first Window, you may from e and i , draw Lines to the accidental Point f , which will give the Bottoms and Tops of all that Row: And then you have nothing to do, but find their Breadth and Distance; and by these Directions draw all the Windows on that Wing of the Building.

If a Statue, Coat of Arms, or other Object was placed at o , *Fig. 33.* and it was desir'd to place the same (or another,) a good Deal higher, as at r ; but so, that the Object when placed at r should appear full as big, as when at o ; being viewed from z .

Observe with the Theodolite, the Angles under which the Object appears at o , as if it was a Statue, observe the Height from the Feet to the Head, &c. and note the Angles with proper Remarks on a piece of Paper; and then by directing the Telescope to r , and setting the Quadrant and Index to the same Angles, you may give Directions how to make the Object at r , of such Dimensions as being viewed from z , will appear of the same Magnitude (or natural Height) with that at o ; & *vice versa*.

The same may be done, if Objects are desired to be placed at a Distance, to appear of the same Size as those that are nearer; with several other Problems to be performed by this Instrument, which the Ingenious will find out in the Use thereof: But I have already exceeded what I intended on this Head, and shall only add two or three Astronomical Problems, which the Surveyor perhaps may find very useful in Practice.



C H A P. III.

P R O B L E M I.

How to find a True Meridian-Line, by Observing with the Theodolite.



THE best Time to make the Observations, are in a clear Day, about 3 or 4 Hours before and after Noon.

In the Morning, having set the Instrument exactly level, move the Index Horizontally, and the Quadrant Vertically, till through the Telescope you see the cross Hairs in the Center of the Sun: Then observe what Degrees and Minutes are cut by the Index, suppose $3^{\circ}, 25'$, which note in a Piece of Paper, as also the Angle of Elevation cut by the Quadrant.

About so many Hours after Noon, observe exactly, that the Quadrant be set to the same Angle of Elevation as in the Morning; and then move the Index on the Limb till you see the cross Hairs cut the Center of the Sun, as in the Morning; and note the Degrees and Minutes which the Index then cuts on the Limb, suppose $64^{\circ}, 37'$.

But Note, 'tis convenient in the Morning to make 3 or 4 Observations 5 or 6 Minutes from one another; because in the Afternoon you must wait till the Sun falls into the same Altitude as it had when you made the Observation in the Morning, (the Quadrant remaining at the same Angle at both;) and if it should happen to be obscured

obscured by Clouds at that Instant, your Labour will be lost for that Day, having made but one Observation in the Morning.

Now, if from $64^{\circ}, 37'$, the Evening Observation on the Limb, you subtract $3^{\circ}, 25'$, the Morning Observation, the Remainder will be $61^{\circ}, 12'$, the half of which is $30^{\circ}, 36'$; to this half Sum $30^{\circ}, 36'$, add the Morning Observation $3^{\circ}, 25'$, and the Sum will be $34^{\circ}, 1'$.

Lastly, the Instrument remaining in the same Position, bring the Index on the Limb to $34^{\circ}, 1'$, and the Quadrant and Telescope will be exactly in the Plane of the Meridian: But if the Observation on the Limb in the Morning, exceed that in the Afternoon, you must add to the Afternoon Observation 360 , and work in like Manner; and if the Remainder should exceed 360 , you must subtract 360 therefrom.

Now observe what Point (on some firm Wall of a Building) is cut by the cross Hairs in the Telescope, there cause a good Mark to be fixed, or cause a Pillar with a Mark thereon to be set up by the Direction of the Telescope: Also take Notice, If you could place the Mark a Quarter or Half a Mile distant from the Instrument, it is better than if it was nearer. And in making these Observations, you ought to be very exact; because when a Meridian-Line is once well fixed, it is very useful for divers Purposes.

Observe, When the Sun is near the Tropicks, the Meridian-line may be found well enough by observing as aforesaid: But when it is near the Equinox, there will be some Variation; because the Sun's Declination is greater or less at different Times in the same Day: And consequently when in equal Altitudes, has different Azimuths. Therefore the Meridian-line may be more truly found, By the *Pole Star*.

The following Table shews the Time from Noon, when the Pole Star makes the greatest Angle from the Meridian-Line towards the East, for any Time in the Year.

January.	February.	March.	April.
D. H. M.	D. H. M.	D. H. M.	D. H. M.
1 23 16	5 20 52	5 19 8	2 17 27
8 22 51	12 20 26	12 18 43	9 17 0
15 22 17	19 19 59	19 18 17	16 16 35
22 21 48	26 19 33	26 17 52	23 16 7
29 21 20			30 15 40
May.	June.	July.	August.
7 15 13	4 13 19	2 11 23	6 9 6
14 14 45	11 12 49	9 10 55	13 8 40
21 14 16	18 12 20	16 10 26	20 8 14
28 13 48	25 11 52	23 9 59	27 7 50
		30 9 33	
September.	October.	November.	December.
3 7 23	1 5 42	5 3 26	3 1 26
10 6 58	8 5 16	12 2 57	10 0 54
17 6 32	15 4 50	19 2 27	17 0 24
24 6 8	22 4 22	26 1 57	24 23 53
	29 3 54		31 23 23

And, to find the Time that the Pole Star will make the greatest Angle on the West of the Meridian; add 11 h. 84 m. to the Time found in the Table: Also *Note*, The Star comes to the same Place about 4 Minutes sooner every 24 Hours, than it did the Day before.

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The following Table shews the greatest Angle which the Pole Star makes with the Meridian in any of these Latitudes, (viz.)

<i>Latitude.</i>		<i>Angles.</i>	
<i>Deg.</i>	<i>Min.</i>	<i>Deg.</i>	<i>Min.</i>
49	00	3	53
49	30	3	55
50	00	3	57
50	30	4	00
51	00	4	03
51	32	4	6
52	00	4	9
52	30	4	12
53	00	4	15
53	30	4	18
54	00	4	21
54	30	4	24
55	00	4	27
55	30	4	30
56	00	4	34

The Time that the Pole Star comes to the East or West of the Meridian, and the greatest Angle which it makes therewith, being found by the preceding Table: Set the Theodolite horizontal, and bring the Index to 360 on the Limb; then turn the whole Instrument about, and elevate or depress the Telescope, till you see the Pole Star in the Intersection of the Hairs therein, and there screw the Instrument fast: Then (if the Observation was made in the Latitude of *London*, 51°, 32') move the Index on the Limb 4°, 6', (as by the Table) towards the Right Hand or Left, according as the Star is Westward or Eastward: And the Telescope will be set exactly in the Plane of the Meridian.

PROBLEM 2.

How to find the Latitude of any Place, by the Theodolite.

THE Instrument being set level, bring the Quadrant and Telescope into the Plane of the Meridian, and let the Index remain at the same Angle on the Limb; then elevate or depress the Telescope towards the Sun, at such Time as you think it is near the Meridian, until you see the cross Hairs in the Center thereof, dividing it as it were into four equal Quarters; and observe exactly what Degrees and Minutes are then cut on the Quadrant, suppose $42^{\circ} 15'$, which note for the Sun's Meridian Altitude.

By an Ephemeris, you may find the Sun's Declination for the same Day, suppose $3^{\circ} 47'$, which if it be North Declination, subtract it from $42^{\circ} 15'$, the Meridian Altitude, and the Remainder will be $38^{\circ} 28'$, the Co-latitude.

But if the Sun hath South Declination, add it to the Meridian Altitude, and the Sum will be the Co-latitude; which subtracted from 90° , gives the Latitude of the Place.

PROBLEM 3:

How to find when the Sun or any of the Stars are upon the Meridian: And the exact Limits of the Natural Day.

HAVING the Co-latitude of the Place, by the last Problem, and the Declination of the Sun given; add the Declination, if North, to the Co-latitude; but if South, subtract it, and the Remainder will be the Sun's Meridian Altitude for

for the Day, as aforesaid, which suppose to be $42^{\circ}, 15'$.

Set the Quadrant to $42^{\circ}, 15'$, and the Telescope will be elevated to the Meridian Altitude of the Sun; then note the Instant of Time by a Watch or Pendulum-Clock, when through the Telescope (remaining at the same Angle) you see the cross Hairs cut the Center of the Sun; for at that Time is the Sun upon the Meridian.

And if you proceed in like Manner the next Day, you will have the exact Limits of the Natural Day, which must exceed or want so many Seconds of 24 Hours, by your Clock or Watch, as appears by the Equation-Table for the Day, if your Clock or Watch goes right.

In the same Manner, you may observe when any Star comes to the Meridian; and if the same Star comes to the Meridian 3 Minutes, 56 Seconds and a half, sooner the second Night than it did the first, your Pendulum-Clock or Watch keeps true Time, & *è contra*. Also if you subtract 3 Minutes, 56 Seconds and a half, for each Night after that on which you made the first Observation, you will have the true Time of that Star's coming to the Meridian for each Night following.

And thus may a Pendulum-Clock or Watch be adjusted to the Mean Motion of the Sun.

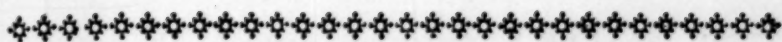
PROBLEM 4.

How the Azimuth and Altitude of any of the fixed Stars are found by the Theodolite.

THE Instrument being set level, and exactly in the Plane of the Meridian, and there fixed, if you direct the Telescope to any Star, its Azimuth is shewn by the Index on the Limb; and the Altitude by the Quadrant both at the same Time.

F I N I S.



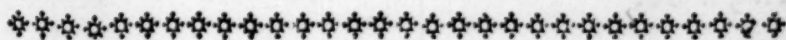


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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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TABLES,

SHEWING THE

ALTITUDE and DIAMETER

OF ANY

OBJECT

To the Hundreth Part of a Foot,
 Answering to every Tenth Part of a Degree,
 throughout the DOUBLE SEXTANT; observed by
 the New THEODOLITE, from a Station of ten,
 twenty, thirty, &c. Feet Distant.

AS ALSO
 The Fourth Part of the Girt of any Timber-Tree
 standing.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100

D. T.	Parts.	D. T.	Parts.	D. T.	Parts.	D. T.	Parts.	D. T.	Parts.	D. T.	Parts.
0	0	5:0	81	10:0	176	15:0	268	20:0	364	25:0	466
1	1	1	89	1	178	1	270	1	366	1	468
2	3	2	91	2	180	2	272	2	368	2	470
3	5	3	93	3	182	3	273	3	370	3	473
4	7	4	95	4	183	4	275	4	372	4	475
5	9	5	96	5	185	5	277	5	374	5	477
6	10	6	98	6	187	6	279	6	376	6	479
7	12	7	100	7	189	7	281	7	378	7	481
8	14	8	102	8	191	8	283	8	380	8	483
9	16	9	103	9	192	9	285	9	382	9	485
1:0	17	6:0	105	11:0	194	16:0	287	21:0	384	26:0	488
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2	21	2	109	2	198	2	290	2	388	2	492
3	23	3	110	3	200	3	292	3	390	3	494
4	24	4	112	4	202	4	294	4	392	4	496
5	26	5	114	5	203	5	296	5	394	5	498
6	28	6	116	6	205	6	298	6	396	6	501
7	30	7	117	7	207	7	300	7	398	7	503
8	32	8	119	8	209	8	302	8	400	8	505
9	33	9	121	9	211	9	304	9	402	9	507
2:0	35	7:0	123	12:0	212	17:0	306	22:0	404	27:0	509
1	37	1	125	1	214	1	308	1	406	1	512
2	38	2	126	2	216	2	309	2	408	2	514
3	40	3	128	3	218	3	311	3	410	3	516
4	42	4	130	4	220	4	313	4	412	4	518
5	44	5	132	5	222	5	315	5	414	5	521
6	45	6	133	6	223	6	317	6	416	6	523
7	47	7	135	7	225	7	319	7	418	7	525
8	49	8	137	8	227	8	321	8	420	8	527
9	51	9	139	9	229	9	323	9	422	9	529
3:0	52	8:0	140	13:0	231	18:0	325	23:0	424	28:0	532
1	54	1	142	1	233	1	327	1	426	1	534
2	56	2	144	2	234	2	329	2	428	2	536
3	58	3	146	3	236	3	331	3	431	3	538
4	59	4	148	4	238	4	333	4	433	4	541
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7	65	7	153	7	244	7	338	7	439	7	547
8	66	8	155	8	246	8	340	8	441	8	550
9	68	9	157	9	247	9	342	9	443	9	552
4:0	70	9:0	158	14:0	249	19:0	344	24:0	445	29:0	554
1	72	1	160	1	251	1	346	1	447	1	556
2	73	2	162	2	253	2	348	2	449	2	559
3	75	3	164	3	255	3	350	3	451	3	561
4	77	4	165	4	257	4	352	4	454	4	563
5	79	5	167	5	259	5	354	5	456	5	566
6	80	6	169	6	260	6	356	6	458	6	568
7	82	7	171	7	262	7	358	7	460	7	570
8	84	8	173	8	264	8	360	8	462	8	573
9	86	9	174	9	266	9	362	9	464	9	575
5:0	87	10:0	176	15:0	268	20:0	364	25:0	466	30:0	577

D. T.	Parts.	D. T.	Parts.	D. T.	Parts.	D. T.	Parts.	D. T.	Parts.	D. T.	Parts.	D. T.	Parts.
30:0	577	35:0	700	40:0	839	45:0	1000	50:0	1192	55:0	1428		
1	579	1	702	1	842	1	1003	1	1196	1	1433		
2	582	2	705	2	845	2	1007	2	1200	2	1439		
3	584	3	708	3	848	3	1010	3	1204	3	1444		
4	587	4	711	4	851	4	1014	4	1208	4	1449		
5	589	5	713	5	854	5	1018	5	1213	5	1455		
6	591	6	716	6	857	6	1021	6	1217	6	1460		
7	594	7	718	7	860	7	1025	7	1222	7	1466		
8	596	8	721	8	863	8	1028	8	1226	8	1471		
9	598	9	724	9	866	9	1032	9	1230	9	1477		
31:0	601	36:0	726	41:0	869	46:0	1035	51:0	1235	56:0	1482		
1	603	1	729	1	872	1	1039	1	1239	1	1488		
2	606	2	732	2	875	2	1043	2	1244	2	1494		
3	608	3	734	3	878	3	1046	3	1248	3	1499		
4	610	4	737	4	882	4	1050	4	1253	4	1505		
5	613	5	740	5	885	5	1054	5	1257	5	1511		
6	615	6	743	6	888	6	1057	6	1262	6	1516		
7	618	7	745	7	891	7	1061	7	1266	7	1522		
8	620	8	748	8	894	8	1065	8	1271	8	1528		
9	622	9	751	9	897	9	1069	9	1275	9	1534		
32:0	625	37:0	753	42:0	900	47:0	1072	52:0	1280	57:0	1540		
1	627	1	756	1	903	1	1076	1	1284	1	1546		
2	630	2	759	2	907	2	1080	2	1289	2	1552		
3	632	3	762	3	910	3	1084	3	1294	3	1558		
4	635	4	764	4	913	4	1087	4	1298	4	1564		
5	637	5	767	5	916	5	1091	5	1303	5	1570		
6	639	6	770	6	919	6	1095	6	1308	6	1576		
7	642	7	773	7	923	7	1099	7	1313	7	1582		
8	644	8	776	8	926	8	1103	8	1317	8	1588		
9	647	9	778	9	929	9	1107	9	1322	9	1594		
33:0	649	38:0	781	43:0	932	48:0	1111	53:0	1327	58:0	1600		
1	652	1	784	1	936	1	1114	1	1332	1	1606		
2	654	2	787	2	939	2	1118	2	1337	2	1613		
3	657	3	790	3	942	3	1122	3	1342	3	1619		
4	659	4	792	4	946	4	1126	4	1346	4	1625		
5	662	5	795	5	949	5	1130	5	1351	5	1632		
6	664	6	798	6	952	6	1134	6	1356	6	1638		
7	667	7	801	7	956	7	1138	7	1361	7	1645		
8	669	8	804	8	959	8	1142	8	1366	8	1651		
9	672	9	807	9	962	9	1146	9	1371	9	1658		
34:0	674	39:0	810	44:0	966	49:0	1150	54:0	1376	59:0	1664		
1	677	1	813	1	969	1	1154	1	1381	1	1671		
2	679	2	815	2	972	2	1158	2	1386	2	1677		
3	682	3	818	3	976	3	1163	3	1392	3	1684		
4	685	4	821	4	979	4	1167	4	1397	4	1691		
5	687	5	824	5	983	5	1171	5	1402	5	1698		
6	690	6	827	6	986	6	1175	6	1407	6	1704		
7	692	7	830	7	989	7	1179	7	1412	7	1711		
8	695	8	833	8	993	8	1183	8	1417	8	1718		
9	698	9	836	9	996	9	1187	9	1423	9	1725		
35:0	700	40:0	839	45:0	1000	50:0	1192	55:0	1428	60:0	1732		

D. T. $\frac{1}{4}$ part of the Girt.

I. T.

0

1 0 : 1

2 0 : 3

3 0 : 5

4 0 : 7

5 0 : 9

6 1 : 0

7 1 : 1

8 1 : 3

9 1 : 4

1:0 1 : 5

1 1 : 7

2 1 : 9

3 2 : 1

4 2 : 3

5 2 : 4

6 2 : 6

7 2 : 7

8 2 : 9

9 3 : 1

2:0 3 : 3

1 3 : 5

2 3 : 6

3 3 : 8

4 4 : 0

5 4 : 1

6 4 : 2

7 4 : 4

8 4 : 6

9 4 : 7

3:0 4 : 8

1 5 : 0

2 5 : 2

3 5 : 4

4 5 : 5

5 5 : 7

6 5 : 9

7 6 : 1

8 6 : 2

9 6 : 4

4:0 6 : 6

1 6 : 8

2 6 : 9

3 7 : 1

4 7 : 3

5 7 : 5

6 7 : 6

7 7 : 7

8 7 : 9

9 8 : 0

5:0 8 : 2

A T A B L E,

Shewing the Fourth Part of the Girt in Inches and Tenths, answering to every Tenth Part of a Degree, so far as ten Degrees.

The USE of these TABLES will appear very plain from one Example.

Measure from the Tree, ten, twenty, thirty, &c. Feet, and there plant the Theodolite Level.

Direct the Telescope to the Bottom of the Tree, and observe the Degree and Tenth of Depression, and to the Top of the Tree, the Degree and Tenth of Elevation.

Then find in the Table, the Parts answering to each, which being added together, make the exact Height of the Tree.

But, because the Fourth Part of the Girt in Inches must be taken in the Middle of the Tree; subtract the Parts answering to the Depression, from half the Height of the Tree: The Remainder seek for in the Table, under Parts, against which, in the left hand Column, is the Degree and Tenth of Elevation; to which, if you set the Telescope, and observe the Diameter of the Tree, *i. e.* the Degree and Tenth on the Limb, answering to the Diameter, and bring them to this Table, you will have the Fourth Part of the Girt in Inches, and Tenths answering thereto.

	D. T.	Parts.
Depression.	24 : 3	451
Elevation.	58 : 8	1651
Height of the Tree.		21.02
Half the Height.		10.51
		451
Set the Telescope. .	31 : 0	600
		$\frac{1}{4}$ part of the Girt.
	D. T.	I. T.
Diameter on the Limb.	9 : 6	16 : 0

N. B. These Tables are calculated for the Distance of ten Feet; yet are they as perfect for twenty, thirty, &c. Feet, only by doubling, trebling, &c. the Length, Diameter, and Fourth Part of the Girt found thereby.

D. T. $\frac{1}{4}$ part of the Girt.

I. T.

5:0 8 : 2

1 8 : 4

2 8 : 6

3 8 : 8

4 9 : 0

5 9 : 1

6 9 : 3

7 9 : 4

8 9 : 6

9 9 : 8

6:0 10 : 0

1 10 : 2

2 10 : 4

3 10 : 5

4 10 : 7

5 10 : 8

6 10 : 9

7 11 : 0

8 11 : 2

9 11 : 4

7:0 11 : 6

1 11 : 8

2 12 : 0

3 12 : 1

4 12 : 3

5 12 : 5

6 12 : 6

7 12 : 8

8 13 : 0

9 13 : 1

8:0 13 : 2

1 13 : 4

2 13 : 6

3 13 : 8

4 13 : 9

5 14 : 0

6 14 : 2

7 14 : 4

8 14 : 6

9 14 : 8

9:0 14 : 9

1 15 : 0

2 15 : 2

3 15 : 4

4 15 : 5

5 15 : 7

6 16 : 0

7 16 : 1

8 16 : 2

9 16 : 3

10:0 16 : 6

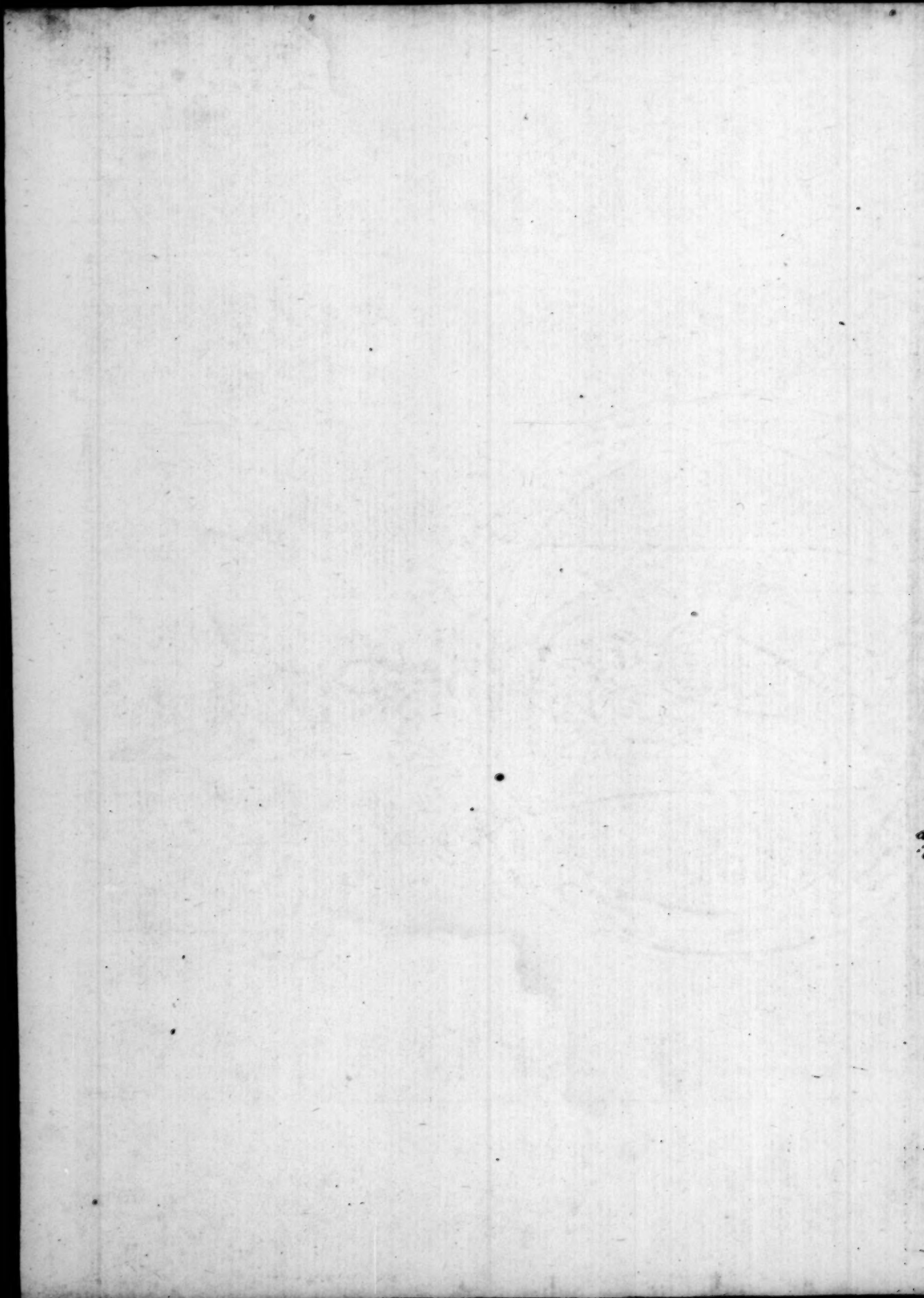


Fig. 1.

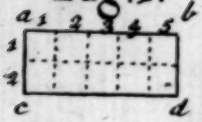


Fig. 2.

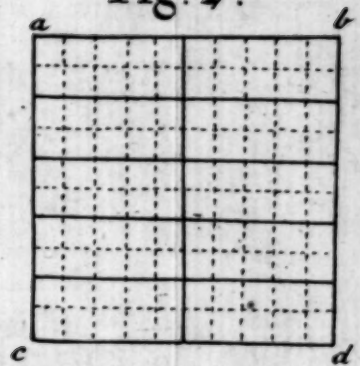


Fig. 3.

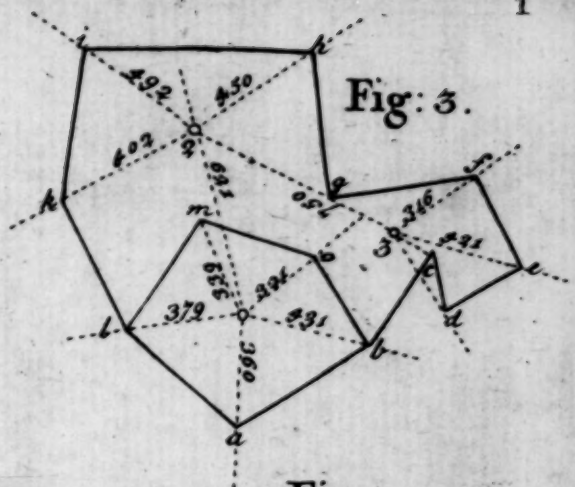


Fig. 4.

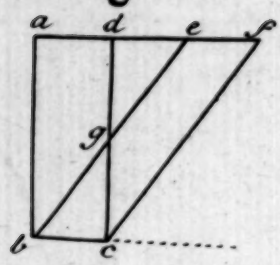


Fig. 5.

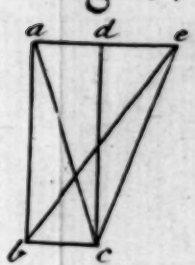


Fig. 6.



Fig. 7.

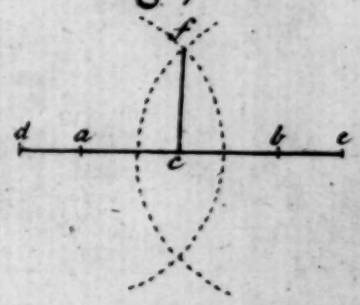


Fig. 9.

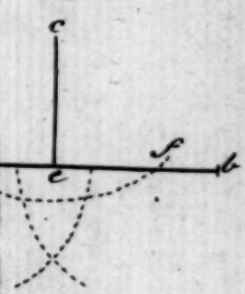


Fig. 8

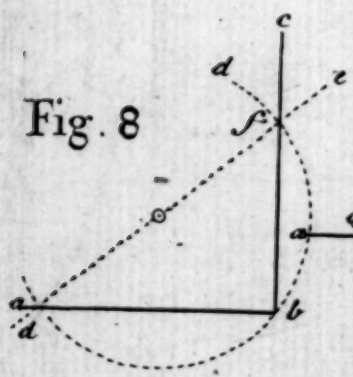


Fig. 10.

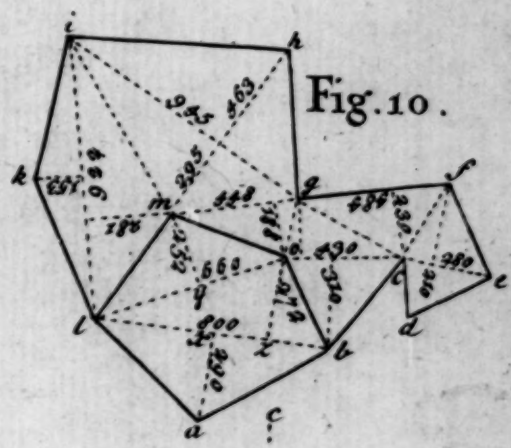


Fig. 11.

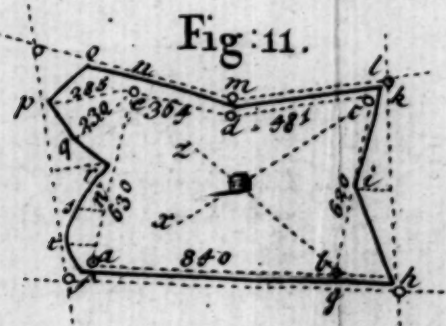


Fig. 12.

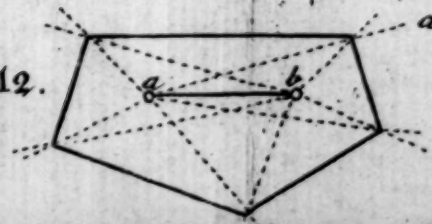
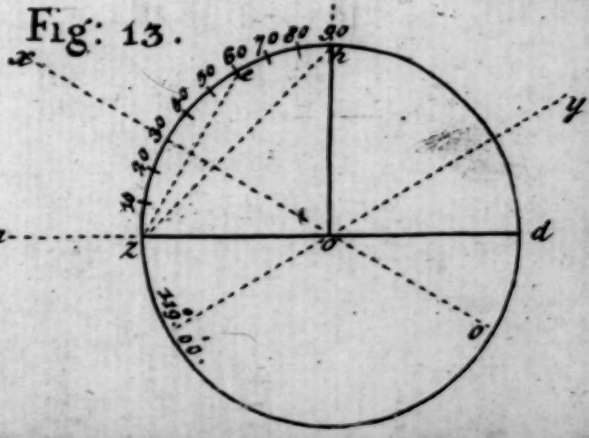
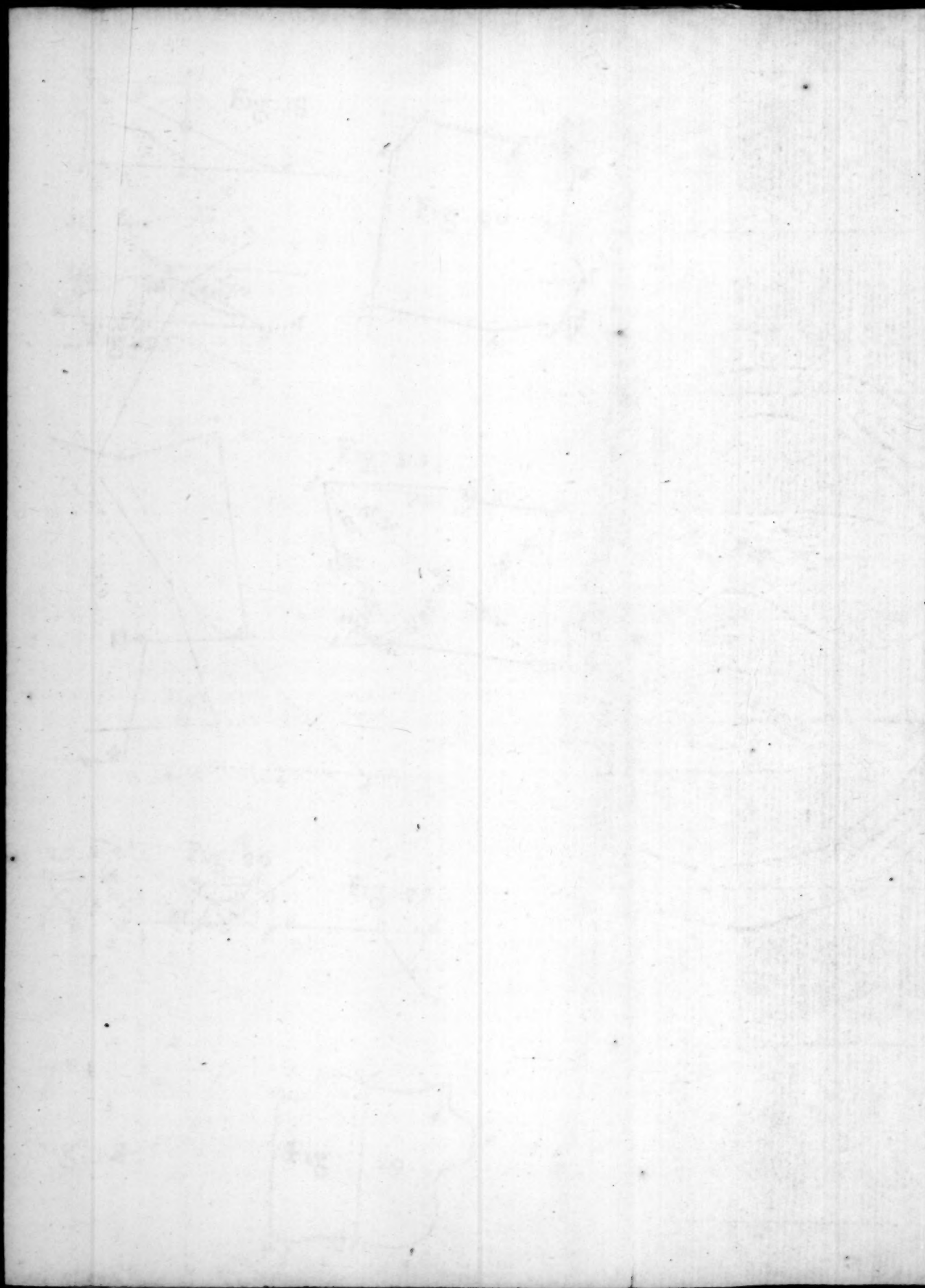
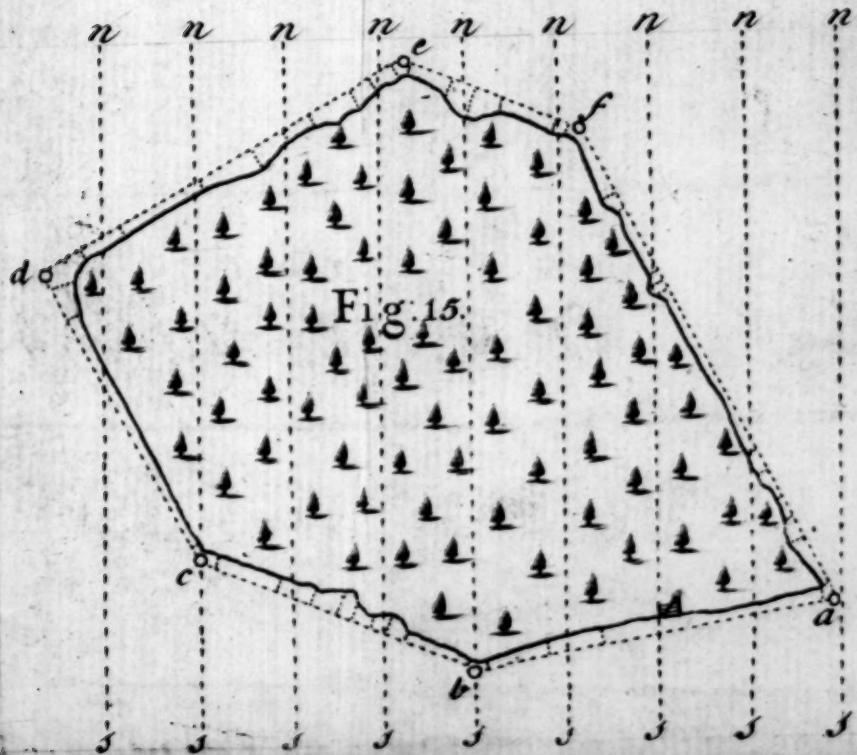
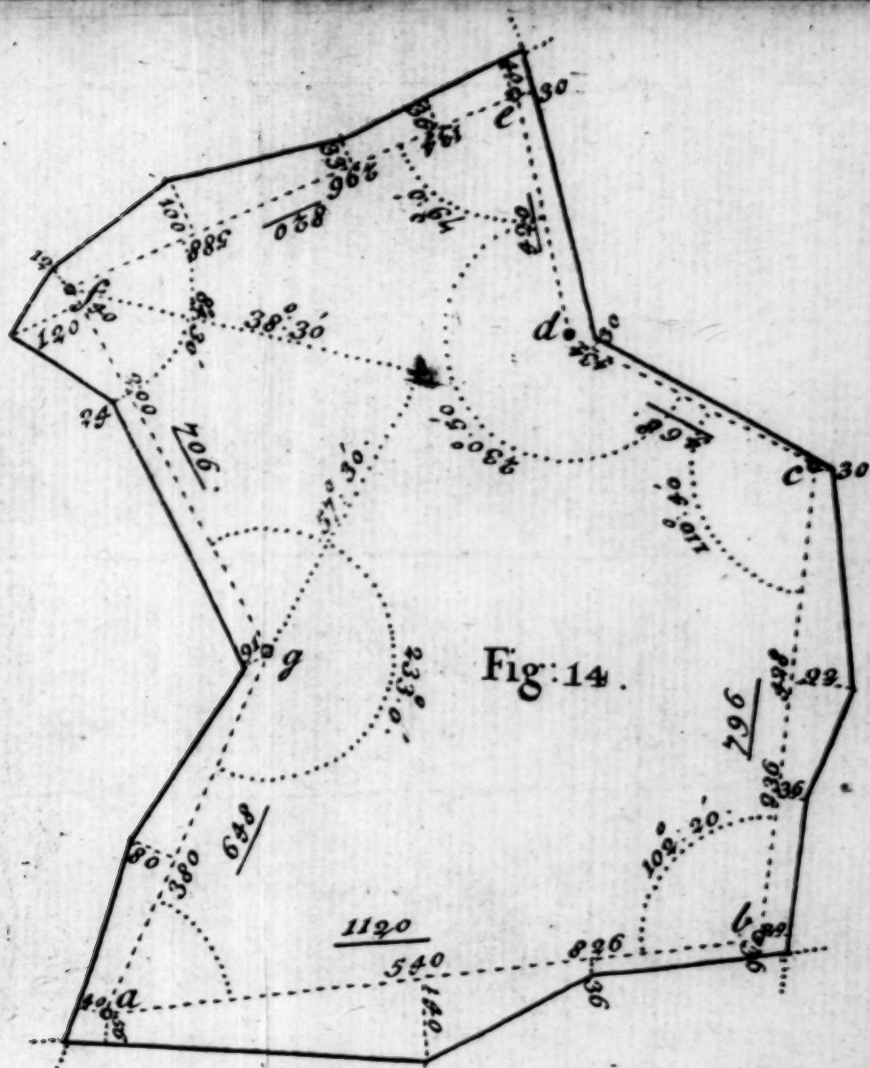


Fig. 13.







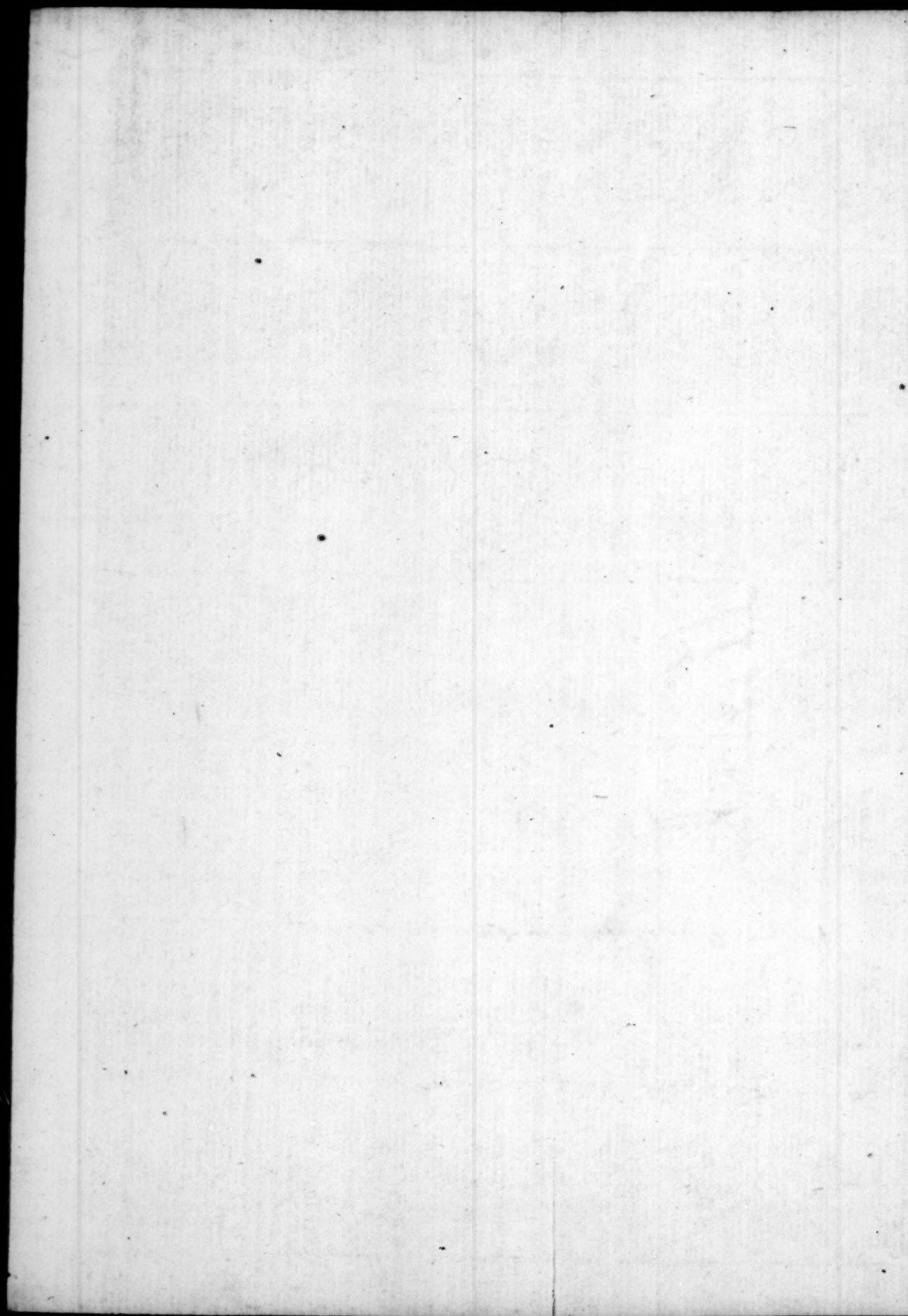


Fig: 17.

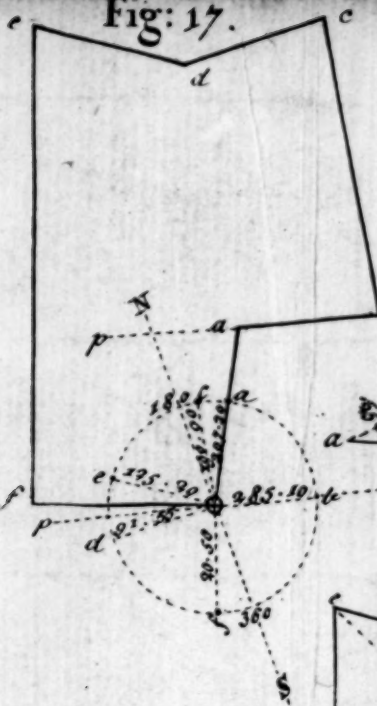


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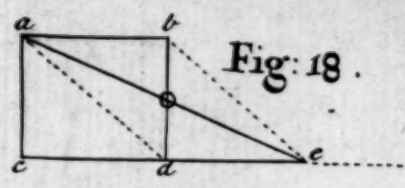


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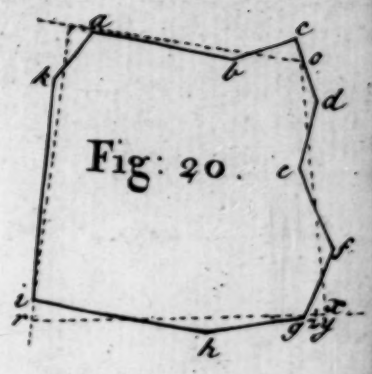


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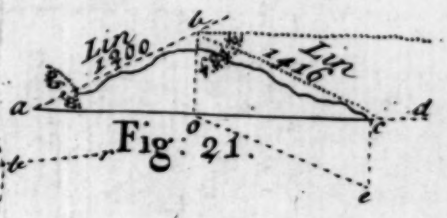


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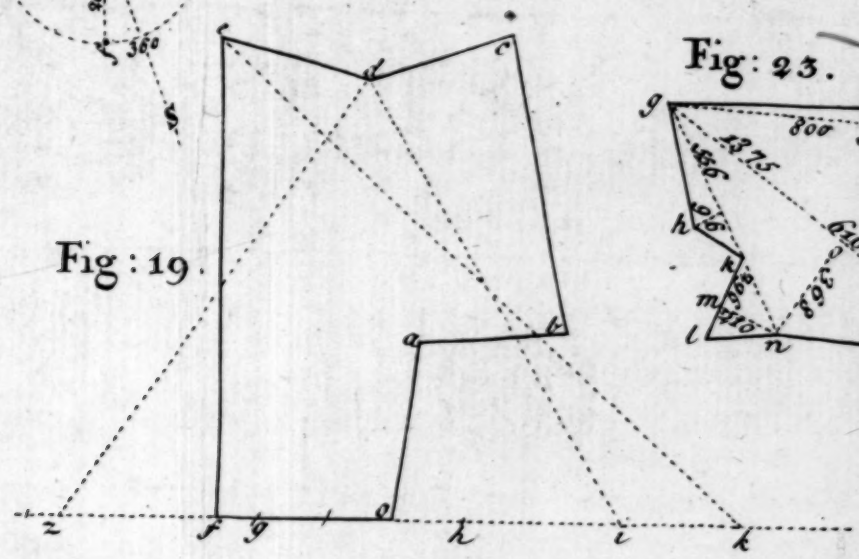


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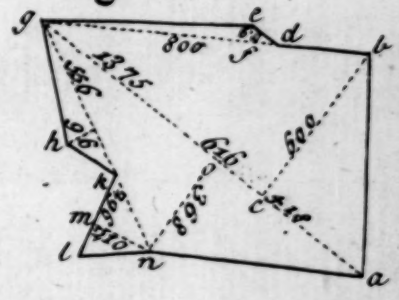


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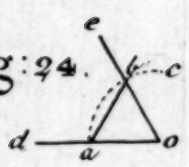


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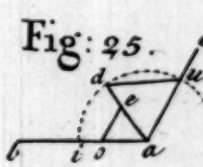


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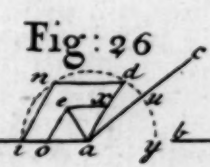


Fig: 27.



Fig: 28.

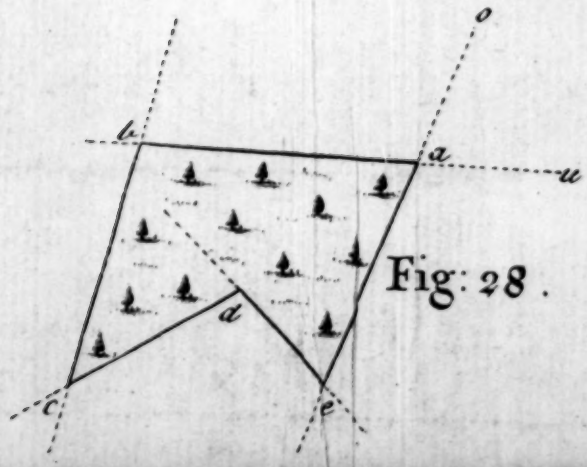


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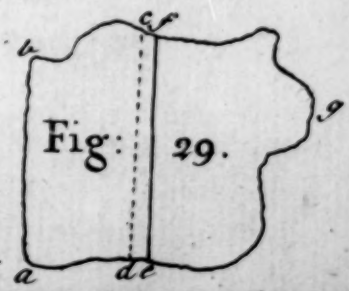


Fig: 22

Henry Branstons Land

Will: Green's Land

Garrot Field

A R P
8 : 0 : 13

Stocki

A R P
6 : 0 : 3

Magg

A R P
7 : 2 : 34

Con

A R P
10 : 2 : 27

Meadow

Pasture

Calve's Croft

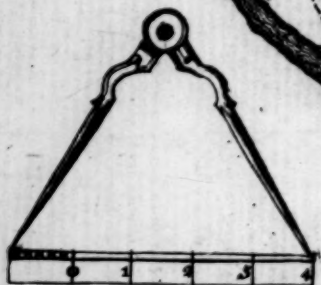
Yard

Orchard

Fu

A
3 :

Charlton Field



John Clemensons Land

Stockin.

R P
0 36

Out-wood

A R P
12 2 27

Home Close

A R P
6 2 18

Crabtree Close

A R P
6 3 28

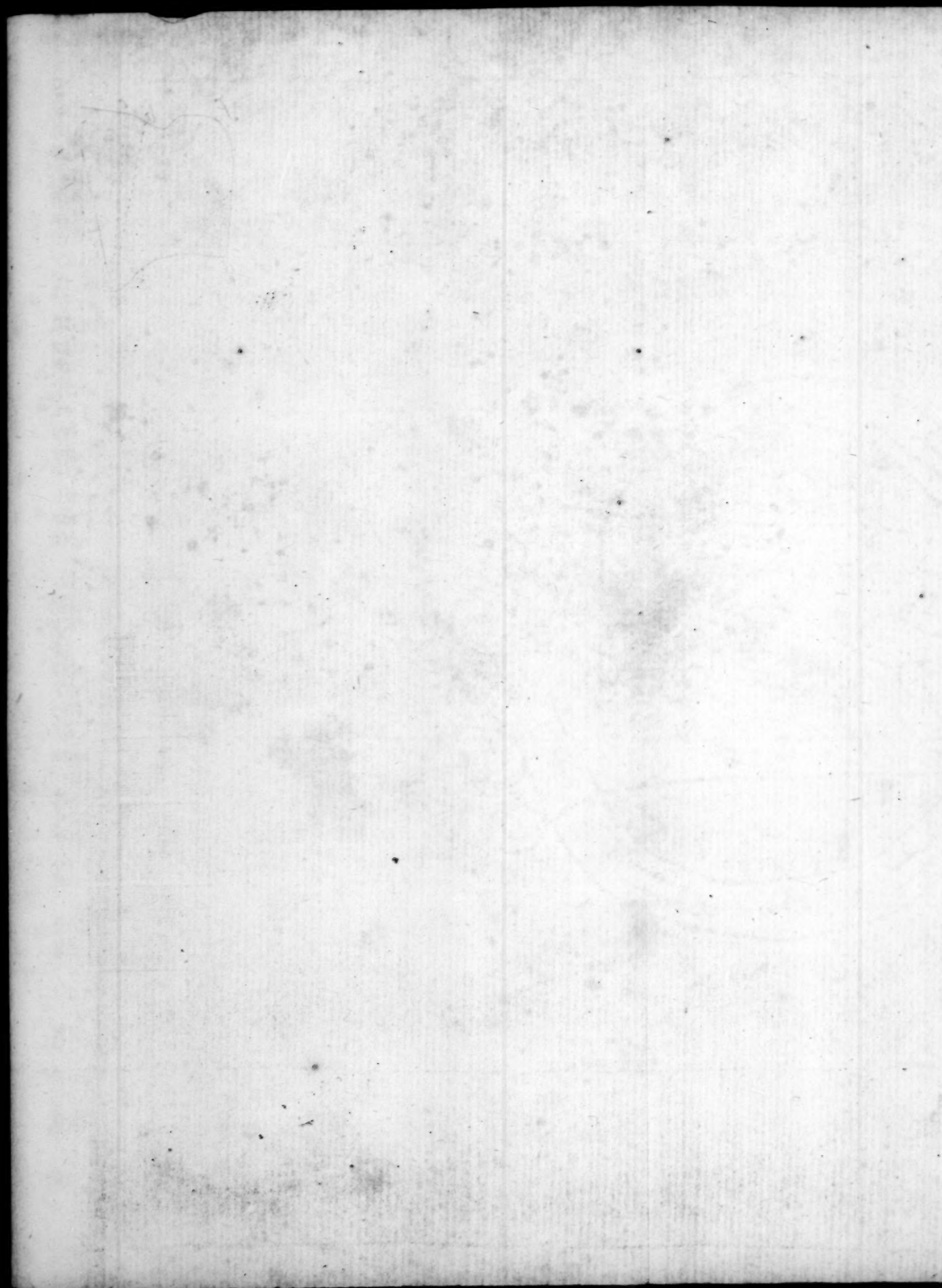
Turfy Lease

A R P
3 0 7

Charlton Conon

Field





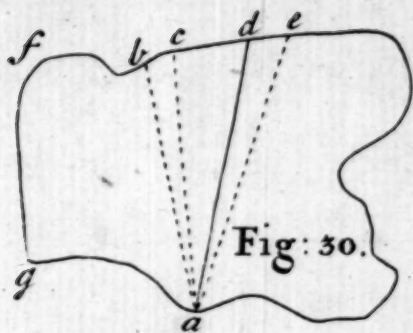


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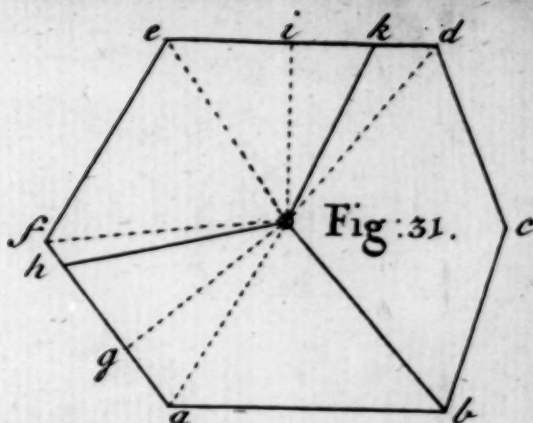


Fig: 31.

Fig: 32.



Fig: 33

